DIMENSIONS NBS

The magazine of the National Bureau of Standards U.S. Department of Commerce

October 1979

SEMICONDUCTORS. See page 12.

COMMENT

INSTITUTE FOR COMPUTER SCIENCES AND TECHNOLOGY

October 1979 marks the first anniversary of the Institute for Computer Sciences and Technology's long range plan to develop Federal computer standards. The history of that plan and its broad general outlines are discussed in this month's DIMENSIONS on page 8.

Some of the actions taken by the Institute during the past year demonstrate our progress in carrying out the plan, and at the same time, illustrate the new directions of the Federal standards program.

First of all, we have issued three new Federal computer interface standards. A fourth interface standard was announced for public comment and is undergoing internal review. The effect of these standards will be to assure compatibility of peripheral devices such as magnetic tape and disk units with central processing units and to improve competition among vendors of peripheral devices.

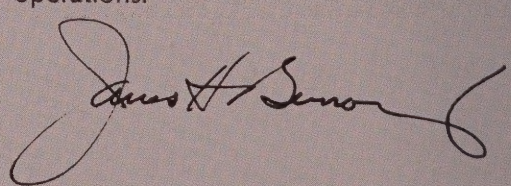
Secondly, we are putting strong emphasis on solving software-related problems. Computer software costs are a major part of Federal ADP expenditures. Two programming language standards—FORTRAN and Minimal BASIC—were announced for public review this summer. When approved, these languages, together with the Federal standard COBOL, will be the high level programming languages that have been standardized for Federal Government use. In 1981, we expect to issue a standard for Pascal, a programming language that is especially useful for mini and microcomputers. In addition, we will be developing validation routines and policies for these languages to assure that compilers procured by the Federal Government perform in accordance with the standards.

Expanding the number of standard programming languages should improve the efficiency and cost effectiveness of Federal computer software operations. Computer programs will be easier to develop and maintain since programmers will have to learn only one set of rules for a programming language. At the same time, programs written in the standard languages can be transferred easily from one computer system to another.

Another effort that we have undertaken to improve the quality of Federal software is an information exchange on software testing and development aids. We are compiling information about the use and availability of software tools and will share that information with software developers and users.

A third significant item has been the development of a contract program with private organizations that accounted for about 40 percent of our funds for the 1979 fiscal year. We expect to continue this work with private companies, universities, and nonprofit institutions. The importance of this effort lies in our ability to reduce reliance on voluntary standards development activities while tapping the considerable talents and ideas of the private sector.

I look forward to reporting future ICST program developments that reduce costs and improve the effectiveness of Federal computer operations.



James H. Burrows
Director, Institute for Computer Sciences and Technology
National Bureau of Standards
A200 Administration Building
Washington, D.C. 20234
301/921-3151

James H. Burrows was appointed director of NBS' Institute for Computer Sciences and Technology (ICST) in May 1979. Before coming to the Bureau Burrows served as associate director of computer resources for the U.S. Air Force headquarters.

DIMENSIONS NBS

The magazine of the
National Bureau of Standards
U.S. Department of Commerce
Volume 63/Number 10

October 1979

Contents

ARTICLES

INTERFACE

UPDATE

FIGHTING FIRE WITH FIRE RESEARCH

Finding Tools for Trimming Fire Losses

10:00 A.M. A folded newspaper is placed on the recreation room couch. A single match ignites the papers quickly.

10:02 A.M. The couch is burning intensely, but the fire still has not spread to the rest of the fully-furnished room. Smoke and gases are collecting at the ceiling. Temperatures are rising rapidly.

10:03 A.M. With a sudden burst of fury, the fire engulfs the entire room. Flames are belching out of the doorway, and the room is now a fiery inferno. FLASHOVER.

by Mat Heyman

THREE minutes. That's how long it takes for a small flame to erupt into a room-sized disaster. The sudden spread of fire from the initial burning object to an entire room is known as "flashover"— often called the "point of no return" in the evolution of a fire. It is also an especially important point for researchers at the National Bureau of Standards Center for Fire Research (CFR), the Federal Government's fire research laboratory. Understanding flashover and the events which lead to it is an important step towards the Center's ultimate goal—to provide cost-effective tools for cutting the Nation's fire losses in half by the 1990's.

Working on the fire problem is an interdisciplinary team including physicists, chemists, an assortment of engineers, mathematicians, psychologists, biologists, and operations researchers. Within the Center for Fire Research, these researchers focus on learning more about the physical and chemical make-up of fires and on developing strategies for preventing, detecting, controlling, and suppressing fires. They pursue a wide range of activities from the most basic research conducted by the Center's Fire Science Division to the applied research found in the Center's Fire Safety Engineering Division.

Heyman is a writer and public information specialist in the NBS Public Information Division.

Of the many elements of fire behavior under study, flashover is among the most important because of the extreme hazard it creates. CFR Director Frederic Clarke puts it this way: "If there are any occupants of the building within several rooms of the fire, their chances of surviving are markedly reduced. Before flashover, extinguishment or escape is likely. After flashover, all bets are off."

Understanding the events which lead to flashover, Clarke explains, helps in developing ways to prevent or delay its occurrence. For example, the rate at which a fire grows can be controlled by careful selection of the materials used in the construction and furnishings of the room.

Full-Scale Tests to Mathematical Models

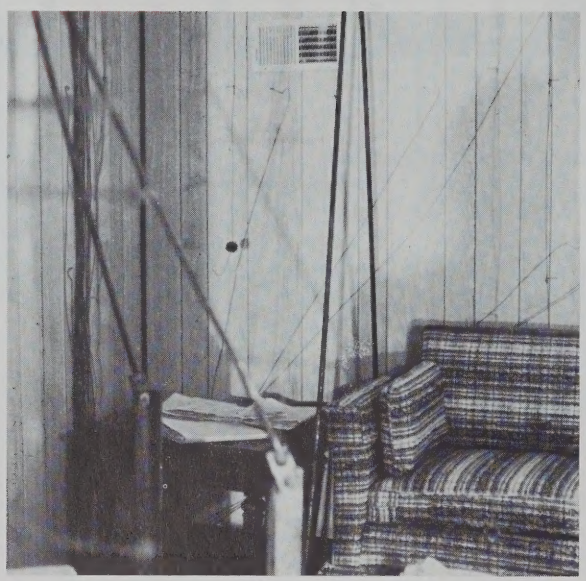
In order to observe and characterize the growth of fire in a room and the time and occurrence of flashover, full-scale tests of room fires are conducted. Bureau researchers design and construct special test rooms in which they can closely monitor and measure the major factors likely to affect how a fire will burn and how materials in the room—including walls, ceilings, flooring, and room furnishings—will contribute to fire buildup.

Through full-scale fire experiments, researchers attempt to predict how a particular room setting will respond when fire breaks out. How thick will the smoke be? How hot will the room get? How many seconds or minutes will elapse before flashover?

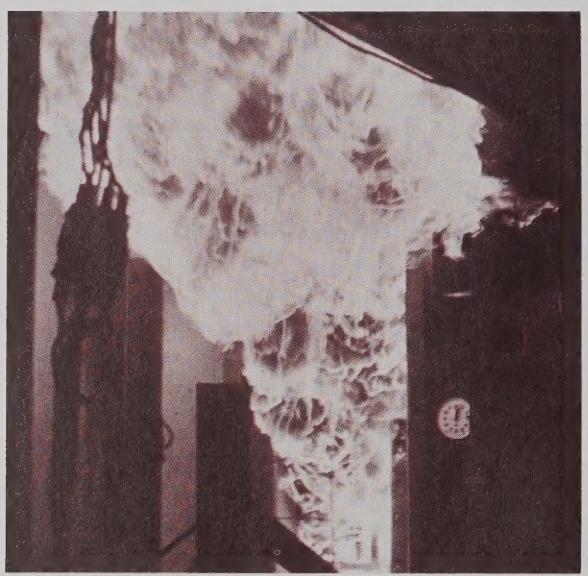
These full-scale tests, however, are both expensive and difficult to perform. A single "room burn" lasting only minutes can cost $10 000 or more to arrange and execute with full instrumentation. This means it is not economically feasible to run full-scale tests to measure how every possible building design or set of room furnishings will withstand a fire. The high cost also prohibits most builders, manufacturers, and regulatory officials from performing full-scale fire tests on every product.

To put fire testing within the reach of more of those who need it, and to bring about more uniformity in testing, researchers at the Center for Fire Research are developing test methods and standards of practice which employ "reduced-size" models to simulate full-sized rooms. NBS work in

turn page



A special "recreation room" has been set up in the NBS fire research facility and instrumented for a full-scale test.



Three minutes after a fire was started on the couch the fire is fully engaged and flames are belching out of the doorway—flashover . . .

. . . and its devastating impact.

this area has been in progress for several years. Today a whole series of small-scale tests are under development with applications ranging from determination of furniture flammability properties to assessment of the possible fire hazards of thermal insulation.

Cutting fire testing costs and providing predictions of the time and occurrence of flashover for a virtually unlimited range of room conditions is also at the heart of another research effort: to develop and refine "mathematical models" of room fires. These potentially powerful analytical tools simulate fire environments with computer programs. Known data about the fire properties of materials used in the construction and furnishing of a room —such as ease of ignition, flame spread, and rate of heat release—are used to predict fire growth.

Some of the simpler computational systems are being verified now, and further research is underway to produce more intricate and flexible ones. When fully developed, tested, and validated by laboratory measurements, these models should result in improved design criteria for the fire safety of materials and buildings. The CFR staff also coordinates fire modeling research at a number of academic, industrial, government, and independent laboratories. Some of these projects are supported directly by the CFR extramural research program, which accounts for one third of the Center's total research through grants and contracts to other laboratories.

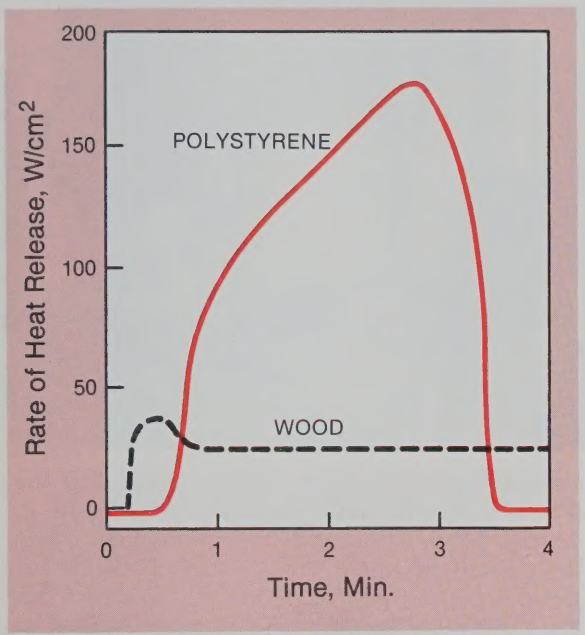
Rate of Heat Release

The rate of heat release (RHR), mentioned above, is one fire property gaining increasing importance as a tool for fire researchers. Better understanding of the contribution of heat release rates to fire propagation has resulted in the use of RHR values in the development of new test methods.

Using a hypothetical example, hazards of two desks—one made of wood and the other of plastic —illustrate the significance of RHR. Although each desk may have the same heat-releasing potential, the wood desk will probably burn much more slowly. The wood desk may take an hour to burn, with the heat from the fire dissipating out of the door and through the floor, walls, and ceiling of the room. On the other hand, the plastic desk is more likely to flame and burn quickly. This causes the temperature of the room to rise too quickly for the heat to dissipate, thus increasing the chances of flashover.

Bureau researchers, in collaboration with guest

A product's rate of heat release can be a critical factor in a fire situation. This graph dramatically illustrates the difference in the rate of heat release between polystyrene and wood samples tested by NBS.



workers from the U.S. and abroad, have developed an innovative method to measure heat release rates that utilizes a substantially different approach than previous techniques. Their work employs a device that measures the amount of oxygen consumed while a sample material burns. The technique relies on the fact that most materials release about the same amount of heat for each unit of oxygen used. The faster oxygen is consumed, the higher the rate of heat release.

While the device—called an oxygen consumption calorimeter—must be validated by additional laboratory tests, it appears to be both more accurate and simpler in design and operation than previous RHR measuring devices. Moreover, since a device based on this principle costs less to produce and operate than previous instruments, it should make heat release testing more affordable for smaller industrial, academic, and government laboratories.

Improved methods for measuring RHR promise to contribute significantly to our understanding of fire in general and to predictions of what will happen in a particular fire situation. Combined with improved data for other fire characteristics such as flame spread and ease of ignition, RHR data will be used with computer models to predict the rate of fire growth that might occur in a particular room and the likelihood of flashover.

Smoke Characterization Detectors

If a fire cannot be prevented, the next best thing is early detection. Knowledge of the properties and components of smoke helps both in the detection and analysis of fire.

For example, a basic study of aerosols and smoke by CFR physicists and chemists led to NBS development of a prototype portable tester suitable for evaluating the sensitivity of installed smoke detectors. Information from these studies also helped CFR engineers to contribute to the essentials of a test method now used by independent test laboratories for smoke detector certification. Similarly, an analytical model of smoke behavior in the buoyant plume above a fire has been developed recently. This model is being used in a larger study of detector siting and sensitivity aimed at improving test methods. The expanded amount of information available to consumers will allow them to select detectors with performance characteristics especially suited to their needs.

From Combustion Toxicology to Human Behavior

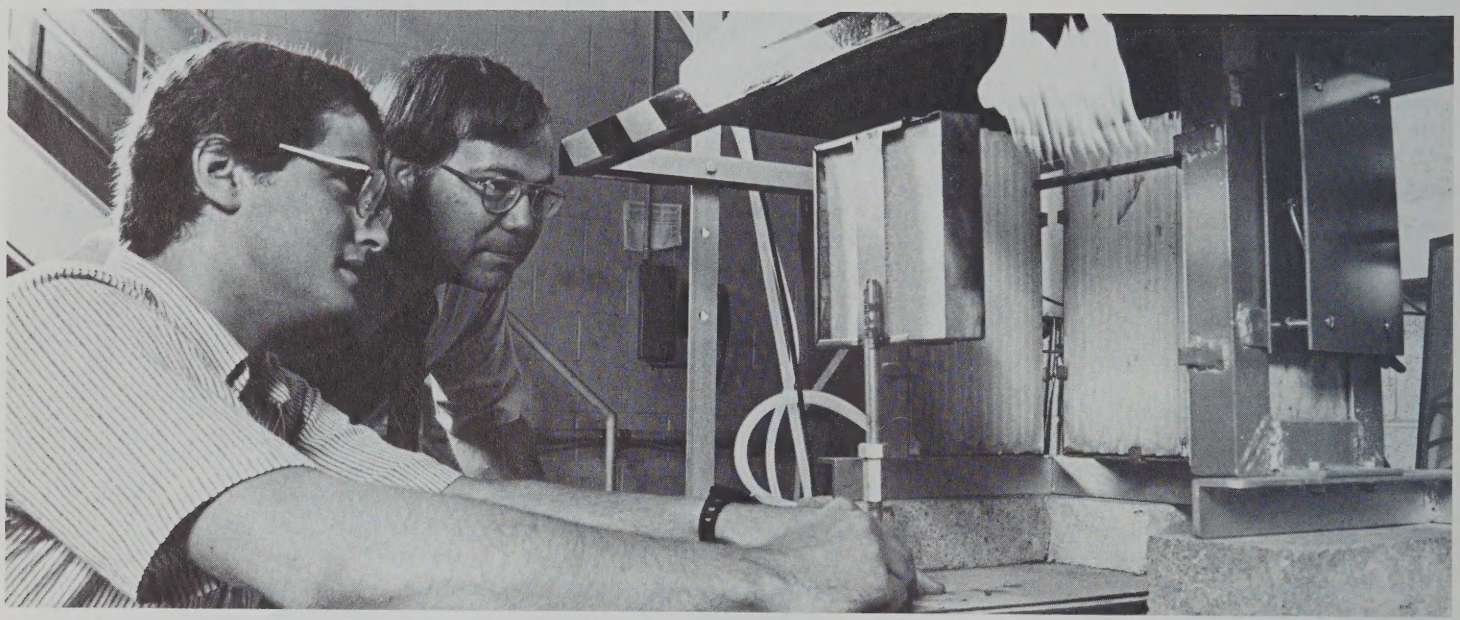
Most fire-related fatalities are associated not with burns, but with the inhalation of toxic combustion products in smoke. CFR-supported research indicates that carbon monoxide—a combustion product from nearly every burning object—is the predominant toxicant in fire injuries and death. Still, it is important that we know what other toxic combustion products are generated by materials, especially those being marketed for the first time.

To this end, NBS has developed a test method for screening the toxicity of materials in a fire. Based on a combination of analytical chemistry and inhalation toxicology techniques, the test method is now being evaluated by several laboratories throughout the country. If proven reliable, the test method will provide a standard way for identifying materials that produce unusually toxic combustion products, permitting designers and regulatory officials to make more informed decisions about materials selections.

CFR also supports a variety of activities relating to human behavior during fires. One University of Massachusetts grant recipient is investigating the effectiveness of smoke detectors in waking residential occupants. Another grantee from the University of Maryland has been identifying and analyzing the behavior patterns of occupants in fires at health care and educational facilities.

Also part of the behavioral program is a study on the psychology of firesetters. Two researchers from the University of North Carolina have de-

turn page



vised a new approach for classifying arsonists according to various psychological qualities. Their work has implications for arson prevention and rehabilitation treatment strategies.

Cost Effectiveness

Extensive fireproofing of every residential, institutional, and commercial building and of every transportation vehicle would do wonders to reduce the current total of 8700 annual fire deaths and more than $5 billion in property losses. But the cost would be astronomical. NBS is trying to develop economically reasonable approaches to solving the Nation's fire problems—not blue sky solutions which cannot be implemented.

The concern for finding cost effective ways to provide fire protection has spurred a relatively new effort in the field of decision analysis. Still in the developmental stages, decision analysis provides a way for researchers to assess the costs and benefits of various fire protection and prevention alternatives. The usefulness of this approach was first shown by the Bureau when applied to the problem of reducing losses associated with upholstered furniture fires, which account for more than 25 percent of all U.S. residential fire fatalities.

The results of fire tests, knowledge of fire behavior, fire loss statistics, and economic considerations were used to compare the relative utility of three alternatives—establishing mandatory smoke detector provisions, mandating furniture flammability standards, or taking no action at all.

The end results depend heavily on the fire loss data that are available and on several assumptions about the cost of complying with flammability standards, the time required to replace existing furniture, and the dollar value assigned to the benefit of saving a human life. Subject to these assumptions, the decision analysis shows that the first two options pose essentially equal costs to society. Ignition standards for upholstered furniture would be more costly in direct economic terms (increased cost of purchasing furniture), but this cost would be offset by the larger number of lives ignition standards would save.

The project is significant because it demonstrates a new method that can be used by decision makers to make quantitative comparisons of different fire safety options. Other decision analysis projects are now being used to study fire protection alternatives in mobile homes, transformer fluids, and the entire problem of residential fire safety.

The NBS Fire Safety Evaluation System is another example of how CFR is striving to ensure that fire safety measures can be attained with greater cost effectiveness. Now ready for use in health care facilities, this evaluation system provides building designers, managers, and regulatory officials with a way of judging the equivalence of fire safety alternatives or building designs with the requirements of the widely used National Fire Protection Association's Life Safety Code. The system may help health care facilities save as much as one-half the amount they would otherwise have to spend to bring their buildings up to presently required levels of fire safety. CFR developed the system with the support of the Department of Health, Education and Welfare as part of a wide-ranging five-year cooperative program addressing fire safety in health care facilities. HEW recently proposed making use of the Bureau's system in all hospitals participating in the Medicare and Medicaid programs.*

For a detailed description of this system, see July/August issue of DIMENSIONS, "Fire Safety for Health Care Facilities —Cutting Costs Without Cutting Corners."

French guest worker Olivier Carret (left) and NBS researcher Randy Lawson with a new oxygen consumption calorimeter that provides measurement of a material's rate of heat release.

Putting Research Into Action

At CFR, there is no such thing as an "ivory tower" approach to solving fire problems. Even the more basic science research about physical and chemical aspects of fire often finds ready application within NBS or other fire research laboratories here and abroad. The very fact that about $3.5 million of the Center's $8.5 million budget comes from other Federal agencies seeking the Bureau's help in solving their own fire problems ensures an immediate use for much of CFR's research results.

Over the past year, researchers at the Center have, among other things:

- Made recommendations to the Department of Housing and Urban Development (HUD) for upgrading their fire safety requirements for mobile homes. These recommendations summarize the results of a cooperative research program extending over nearly five years and involving 90 full-scale tests by CFR on mobile home fires.
- Seen the Consumer Product Safety Commission adopt two new tests for judging flammability of thermal insulation that are based on NBS research and test methods.
- Carried out pilot training of HEW officials in the Bureau's Fire Safety Evaluation System, now proposed for wider use by that agency. A more extensive training program is now being developed by the U.S. Fire Administration in coordination with the Center.
- Examined the use of sprinklers in health care facilities. CFR tests for HEW have suggested that while sprinklers are a useful fire protection tool, they should not always be relied upon as the principal device for preventing flames and toxic gases from reaching patients.
- Assessed the fire safety of "people movers" for the Department of Transportation.
- Aided CPSC in its consideration of the furniture flammability standard developed by NBS several years ago.
- Analyzed the fire safety problems associated with wood-burning stoves and fireplaces.

Nor does the Center restrict itself to working with Federal agencies. In addition to the various research associates and guest workers who join the Bureau research staff on temporary assignments, CFR participates on a daily basis with industry through voluntary standards organizations such as the National Fire Protection Association and the American Society for Testing and Materials. NBS serves as a technical resource for these groups. The staff of the Center also maintains regular contact with international research groups and standards organizations, as well as with model building code organizations and State and local regulatory authorities.

Controlling the number and severity of fires in the United States is a mammoth task. "If the United States is serious about reducing fire losses," says Center for Fire Research Director Clarke, "we need to know more about the science of fire and about new fire-related technologies. As we fill these gaps in our knowledge, we will have a better idea where fire prevention measures can be improved." □

Has a report been published on mattress fires? Is there a technical text available on smoke detectors? If you need answers to questions like these, you should contact the Fire Research Information Service (FRIS) at the National Bureau of Standards. The staff of this Federal information service handles requests from both the Center for Fire Research at NBS and from others interested in fire research.

In 1971, NBS started to develop a fire safety data base on contract to the National Aeronautics and Space Administration. This was the beginning of an organized, catalogued fire research collection at NBS. Today the FRIS collection consists of approximately 25 000 books, journals, and reports from all major countries involved in fire research. Topics of interest include building fires, hazard analysis, toxicology, mine fires, offshore platform fires, physics and dynamics of fire, and modeling of fires.

Printed materials on these and other subjects are distributed through FRIS to interested researchers. *Fire Research Publications* lists NBS fire reports as well as outside works by the CFR staff that are part of the FRIS collection.

Free loans of FRIS materials are arranged through the Interlibrary Loan Program, and your librarian can provide details about this library network.

Requests for further information should be directed to: Fire Research Information Services, National Bureau of Standards, Building 224, Room A263, Washington, D.C. 20234, 301/921-3246.

by Shirley Radack

THERE is a new look to the Federal computer standards program. With recent changes in overall structure and direction, this program focuses more sharply than ever on goals of improved Government economy and efficiency.

Federal computer standards are authorized under the Brooks Act of 1965 which has as its goal the "economical and efficient purchase, lease, maintenance, operation, and utilization of automatic data processing equipment by Federal departments and agencies." Under this legislation the Department of Commerce is charged with developing and issuing uniform automatic data processing (ADP) standards, providing scientific and technical advisory services for ADP, and performing necessary computer science research. The Office of Management and Budget has overall management responsibility for issuing Government-wide policy and exercising budgetary review of the standards program. Implementing Federal ADP standards in the procurement process falls within the responsibilities of the General Services Administration.

The Secretary of Commerce issues Federal ADP standards on behalf of the President; these standards are intended to be mandatory for all Federal agencies. The management of the computer standards program and the scientific and technical activities—assigned to the Department of Commerce by the Brooks Act—are carried out by the National Bureau of Standards through the Institute for Computer Sciences and Technology (ICST).

The Federal Government is one of the world's largest computer users. It owns or leases over 12 000 computers, staffed by more than 150 000 technical personnel. The General Accounting Office estimates that the Government spends over $10 billion per year for ADP equipment, services, and salaries of technical personnel. About 50-70 percent of these

Radack is in the Office of the Director, NBS Institute for Computer Sciences and Technology.

"We believe the Federal Automatic Data Processing Program needs to be strengthened to achieve greater efficiency and economy."

costs are for software development and maintenance.

Today, as in 1965 when the Brooks Act was adopted, computer standards are important tools for helping to control ADP expenses. Computer standards:

- make it possible to procure computer components and systems in a competitive process and achieve cost savings;
- assure the proper operation and compatibility of components procured from independent sources;
- provide practices and techniques to improve the utilization of computer resources.

In recent years, studies of Federal automatic data processing systems have affirmed the link between standards and improved economy in the procurement and use of computers, and have pointed out the need for the right standards at the right time.

In a 1976 report on the procurement of ADP resources, the House of Representatives Committee on Government Operations recommended that NBS "develop necessary hardware and software standards to insure maximum economies and efficiencies in the procurement and utilization of ADP resources."

The following year, officials of the Office of Management and Budget in a letter to Representative Jack Brooks, Chairman of the House Government Operations Committee, said, "We believe the Federal ADP Standards program needs to be strengthened to achieve greater efficiency and economy. Such strengthening of the standards program must, however be accomplished in a manner which will not stifle competition or preclude the Government from taking advantage of new technology."

Echoing the call for action, the General Accounting Office said, in a 1978 report to Congress,* "Federal agencies have become locked into suppliers of computers and related services either because essential standards have not been developed or agencies are not complying with existing standards. As a result they are making noncompetitive procurements to avoid extensive efforts to convert their computer programs and data. Conversions now cost the Government an estimated $450 million every year."

Then, in 1978, the President's Reorganization Project for Federal Data Processing, an in-depth study conducted by 55 computer professionals from both the public and private sectors, examined Federal uses of information technology. One task force, focusing specifically on computer standards, recommended that the Federal Government "promote the adoption and acceptance of authoritative, workable standards for information processing to facilitate the cost-effective use of the technology within the government."

Barriers to the development and use of timely standards have been identified in the above studies and by ICST assessments of the standards process:

—ADP standards efforts have relied heavily on voluntary industry activities. These activities are often slow, and government needs for standards are not always given priority by voluntary standards groups;

—there is little information on the costs and benefits to be achieved through the use of standards;

—there have been no established procedures for assigning priorities for standards development based on expected cost savings and operational improvements;

—the impact of standards on Federal agencies and private companies is not known.

As a result of these critical looks at the kinds of standards that are needed, ICST developed a long-range plan for the program. With the support of OMB and Congress, ICST was given an increase in funds from approximately $4 million for the 1978 fiscal year to approximately $11 million for the 1979 fiscal year to begin implementation of the plan.

The NBS Institute for Computer Sciences and Technology was given an increase in funds from approximately $4 million for the 1978 fiscal year to approximately $11 million for the 1979 fiscal year.

First of all, the computer standards plan establishes priorities for standards based on technical analysis of their potential for reducing ADP costs and improving operations. It focuses on the Federal Government's special needs for computer standards and provides the means for independent government actions to develop standards when voluntary industry activities do not match government needs. Technical and economic studies of the impact of standards play an important part in the planning and development process.

Participation in voluntary standards development will continue to be supported; however, other approaches to standards development will be used to carry out the overall plans when Federal needs are not met. For example, an extensive effort is underway to arrange contracts with private research and development firms to develop the technical

turn page

**The Federal Information Processing Standards Program: Many Potential Benefits, Little Progress, and Many Problems; General Accounting Office, April 19, 1978, FGMSD-78-23.*

foundation for standards and to provide technical and economic analyses of standards. Specific projects have been identified and requests for proposals are being solicited. Approximately $4.5 million of ICST's 1979 funds will be spent on contract work.

Ten high priority standards "families" have been identified. (See box.) About 70 individual standards in the first five families have been selected for development. Voluntary industry efforts are addressing about 55 percent of these standards, and ICST is monitoring and supporting these activities through participation in technical committees. With its substantial increase in operating funds, ICST will provide for the technical development of the remaining standards in a variety of ways: by direct involvement of the ICST technical staff; through contracts with private firms; by working with other Federal agencies ; and by organizing interagency committees and task groups.

Another important change in the computer standards program reflects the fact that computer technology is changing rapidly. ICST plans periodic reviews of the standards families to assure that the selected work areas keep pace with technological developments. Technical forecasts will be developed to provide the foundation for future standards planning and as a guide to Federal agencies.

The participation of the Federal agencies in the standards development and implementation process has been given renewed emphasis. Recently in a memorandum to the heads of Executive departments and agencies, OMB stressed that "a sound Federal information processing standards program can improve efficiency and produce significant savings for the American taxpayer." OMB asked Federal agency directors to appoint a "senior management official who will be responsible for developing (agency) policies and procedures and overseeing their implementation." ICST is establishing close working relationships with these officials to help identify agency ADP problems and to evaluate the effectiveness of existing standards. The automatic data processing standards needs of individual agencies will be used by ICST in guiding future work plans.

In addition to developing the technical specifications for standards, ICST will develop and publish with proposed standards or families of standards an assessment of technical impact and an analysis of costs and benefits. These studies will be made available for public comment and review just as the standards themselves are.

The first such analysis has been published for a group of four interface standards* that apply to input/output channel level interfaces of all medium and large scale computer systems procured by the Government. The study** projects that the new standards will produce cost savings of $61 million over the next 5 years in the procurement of new peripheral equipment.

To help achieve the maximum Government-wide savings, ICST is exploring procedures for measuring and reporting on agency use of ADP standards. Data is being compiled from a variety of sources to provide a picture of standards implementation and use. General Services Administration data on the use of standards in ADP procurement are being analyzed. Agency requests to be exempted from the provisions of standards in procurement actions and operations are also being analyzed. In addition, ICST is working with agency senior management officials for the standards program to set up a pilot study for collecting data on standards usage.

An annual report on the ADP standards program will be issued by the Secretary of Commerce covering accomplishments and plans for the program, funding information, and other data related to Government computer standards activities.

Some changes in ICST's internal organization have been made to enable the Institute to carry out the restructured standards program. A program development office was established to plan the Institute's programs, monitor its progress, and conduct needed studies and analyses. Two new centers—one for Programming Science and Technology and one for Computer Systems Engineering—have been created to carry out ICST's Brooks Act responsibilities more effectively.

The restructured computer standards program is geared to accomplish what government leaders have said is needed, a way of reducing automatic data processing costs and improving productivity in Government. ICST Director James H. Burrows says that he is pleased to "contribute to an area that is increasingly important to improving Government economy." He sees the years ahead as critical ones for assessing the new approaches and new directions of the Federal computer standards program. □

---

*FIPS 60, I/O Channel Level Interface.
FIPS 61, Channel Level Power Control Interface.
FIPS 62, Operational Specifications for Magnetic Tape Subsystems.
FIPS 63, Operational Specifications for Rotating Mass Storage Subsystems.

**"A Cost Benefit Analysis of Proposed Federal Input/Output Channel Level Interface Standards" (NBSIR 78-1487).

Where Standards Can Save the Most

Supported by a substantial budget increase for the fiscal year 1979, the NBS Institute for Computer Sciences and Technology has initiated an expanded computer standards development program. ICST's long range plan for standards development identifies the following "families." These groups have been selected, based on a technical analysis of their potential for reducing automatic data processing costs and improving operations:

- **High-level programming language standards** to reduce the costs of converting software that is specific for one particular system for use on other systems, to improve programmer productivity, and to enhance nonspecialists' use of computers.

  Includes standards for existing languages with business and scientific applications, improved languages for general use, software development methods, system command and response, and data transfer.

- **Software quality control standards** to improve the quality of software through error reduction and early error detection and to improve the portability of programs.

  Includes standards for management and control of software development projects, the analysis and design of software, software testing and documentation.

- **Computer system and network interface standards** to improve the economic acquisition of network systems and components through more competitive procurements and to assure reliable and efficient operation of equipment and components.

  Includes specifications for the operation of computer system peripheral devices with the standard interface for large and medium scale systems, standards for mini and microcomputer interfaces, data communications, network protocols, local networking and office systems, data interchange, and network service interface measurement.

- **Data base management standards** to improve portability of database systems, to improve economic acquisition of data base systems through more competitive procurements, and to improve effective use of these systems.

  Includes standards for data definition, manipulation and query languages, management and control of database systems.

- **Computer security and risk management standards** to protect information and reduce risks and vulnerability in computer systems and networks.

  Includes standards for computer system physical security, access controls, and data encryption to protect information transmitted between computers.

- **Performance measurement and evaluation standards** to increase the efficiency of computer systems and networks.

  Includes standards for testing systems in competitive procurements and reviewing systems for efficient operation.

- **Data standards** to facilitate the interchange of data in machine sensible form and to reduce the costs of Federal computer operations by eliminating unnecessary duplication and incompatibilities.

  Includes standards for the identification and definition of data elements, their presentation and structure.

- **Computer system functional specification standards** to improve the economical acquisition of computer systems through more competitive procurements.

  Includes standards for specifying computer system functions for procurement activities.

- **Performance assurance standards** to improve economy and accuracy of computer system operations by assuring that only intended and correct functions are performed.

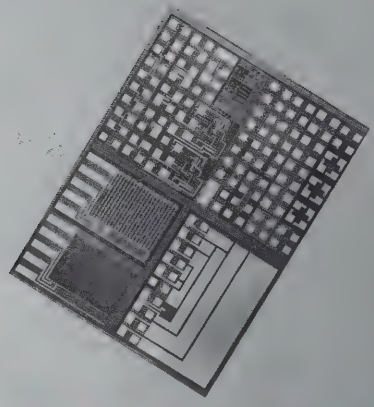
  Includes standards for audit and evaluation of computer system performance.

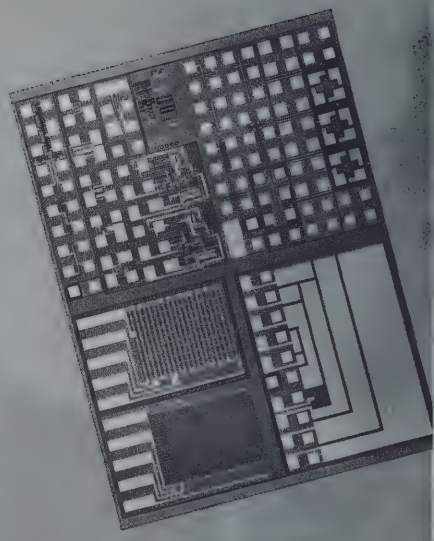
- **Management standards for Federal large-scale computerized models** to improve the management of Federal computerized models.

  Includes standards for model documentation, specification, development, and procurement.

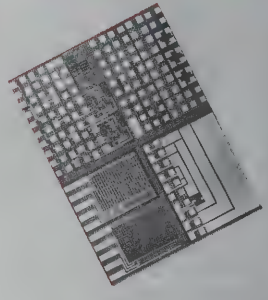
COVER STORY:

The picture on the front cover shows a high temperature diffusion furnace used to "dope" semiconductor materials with impurities. See page 14 for more about how semiconductor devices are made.





A LITTLE LESS WITCHERY,



by Michael Baum

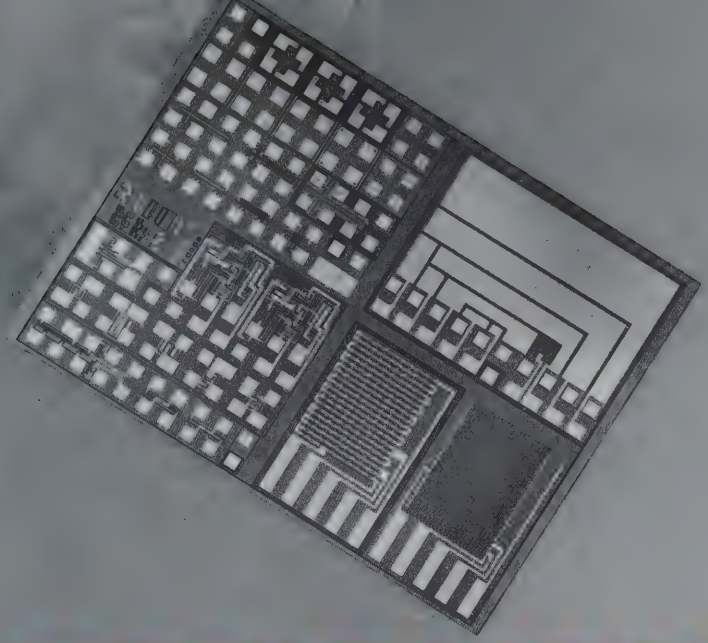
"AT the heart of this, it's really witchcraft, though you may think of it as high technology."

The speaker is Martin Buehler, an electronic technology specialist at the National Bureau of Standards, and his subject is semiconductor manufacturing: the construction of those miracle chips of electronics that do everything from pacing car engines and human hearts to making computers work.

"You think of the manufacturing process as high technology, but if you were to go into some of the large factories, correcting problems in the production process is more like witchcraft. When something goes wrong, a process engineer says something like, 'Let's try running the furnace a little hotter.' "

Buehler and a handful of other specialists in the Center for Electronics and Electrical Engineering are trying to replace this kind of trial and error approach to semiconductor quality control with reliable methods for testing these tiny electronic circuits.

Baum is a writer and public information specialist in the NBS Public Information Division.



A LITTLE MORE CRAFT

Improvements for Semiconductor Quality Control

What They Are and What They Do

Semiconductors are a special class of materials that conduct electricity better than insulating materials but not as well as metals. They are used as the basic building materials for microelectronic circuits because of their versatility for channeling electric currents.

The most widely used semiconductor material is silicon, a hard, dark gray, lightweight solid. When used to produce integrated circuits, silicon in the form of a long single-crystal cylinder is sliced into round thin "wafers." By "doping" silicon wafers with tiny amounts of impurities in selected regions, manufacturers can change the electrical properties of these materials with a high degree of precision. The difference in the electrical conduction of the various doped regions can be used to create transistors or "switches" which can influence the pathways that electrical currents follow through the silicon. These switches can be made to repeatedly turn on and off in a controlled way. When arranged in a special array, the on/off effect of transistors can be used to mimic the functions of mathematical equations.

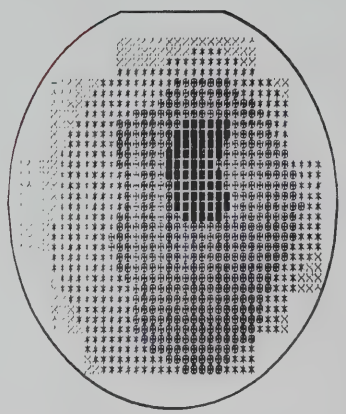
The use of such arrays of transistors, called integrated circuits, in the manufacture of electronic instruments and systems has revolutionized the industry. Modern integrated circuits include as many as tens of thousands of circuit elements on a silicon chip about four times the size of a capital "M" on this page. Each of these elements also includes several very thin layers of different materials.

Smaller is Better—But Harder

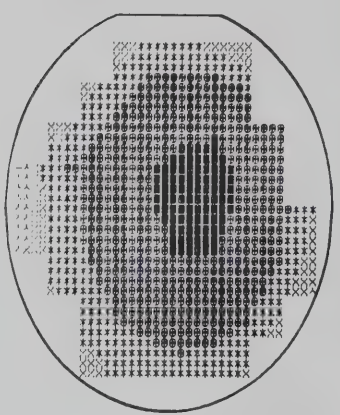
Fabricating a piece of electronics with so much in such a small space presents enormous design problems. Often computers are needed to find the solutions. But even a properly designed circuit poses several manufacturing problems as well. The astoundingly small scale of these devices requires production processes which strain the physical limitations of the materials. Even misplaced atoms within the silicon crystal or an unseen speck of dust can hamper the performance of the finished product.

The "wires" used to connect individual elements of each circuit are actually fine lines of metal which are "printed" on the silicon. The width of these lines averages about 4 to 6 micrometers, says Buehler, "with some manufacturers pushing 2 to 3 micrometers and a few labs experimenting with 1-micrometer widths. The thickness of a human hair is about 60 times the width of a 1 micrometer line." A small error in the alignment of the photomasks used in forming the "wires" and other elements of the circuit can result in improper or broken connections.

turn page



Map showing the resistance of one layer of a process validation wafer (PVW) covered with NBS-7 test patterns. Lighter areas depict lower resistance, while darker ones depict higher resistance.



Map showing the gain of the same layer for the same PVW. The similarity between the two patterns tells a semiconductor process engineer that the gain of the transistors in the wafer can be controlled by changing the resistance of this layer.

Precise control is also needed when forming transistors with trace amounts of impurities. The phosphorus or boron used to dope the silicon must be correctly placed in exactly the right quantity. Minute variations in the concentration of dopants in different portions of the silicon wafer can ruin the tiny circuits.

"The impurity density at present," says Buehler, "can be as low as a few parts per million—like sprinkling a few grains of salt on top of a boxcarload of sugar."

All of these fine tolerances are potential sources of trouble in the multi-stage construction of an integrated circuit. (See box for detailed explanation.) And because of the extreme complexity of each integrated circuit chip (some are now the equivalent of a small computer) and their numbers (up to several hundred on a single wafer), individual testing of each chip is an expensive and somewhat futile occupation.

"You cannot," Buehler observes, "thoroughly test these systems."

"Our work revolves around devices and techniques that permit the manufacturer to control the production process, and in that way to assure the quality of the product."

turn page

How Semiconductor

The successful manufacture of semiconductor test patterns is a delicate and painstaking process. The photos on pages 15 through 19 and the diagram below show how it is done in the NBS Center for Electronics and Electrical Engineering. Although this is only a comparatively small research operation, the principles and techniques employed for making test patterns are similar to those used by most commercial manufacturers for making semiconductor integrated circuits.

The test patterns are built in stages by a technique called *photolithography* which includes aspects of both lithographic and photographic printing. Each structure within the pattern includes several layers, with one layer laid atop the next. Each layer requires a separate transparency or photomask which contains the design for that layer.

The designs for NBS test structures are originally drawn by hand, many times their final size. The photos on page 17 show Kerry Fischer entering a test structure design into the computer memory. She uses a special drafting board called an automatic digitizer. As the pointer on the drafting board is moved across the drawing, the key points of the design are automatically converted to a set of coordinates in the computer and stored on magnetic tapes. The tapes are used to control a pattern generator which makes the photomasks for each layer of the test pattern.

In the meantime, wafers are cut from a blank cylinder of pure silicon crystal using a special circular saw blade that cuts with its inside edge rather than the outer one. The wafers are about the thickness of a fingernail or ¼ millimeter (mm) thick. The wafers shown are 50 mm in diameter, sufficient for testing purposes. Commercial wafers may be as large as 75 to 100 mm in diameter.

The cut wafers are separated and polished. NBS technician Louie Robinson is shown on page 18 holding a polishing disk with six wafers mounted on it. After polishing, the wafers are taken to a "clean room"—where dust levels are kept as low as possible—and washed.

The wafer is now ready for the photolithography process. The accompanying diagram shows how this is done for a comparatively simple device, a metal-oxide-semiconductor field effect transistor, or MOSFET. A

Test Patterns Are Made

thin, insulating layer of silicon dioxide is formed on the surface of the wafer when it is heated to 1000 °C in a special controlled-atmosphere furnace. (A*)

The wafer is then covered with a thin layer of a light-sensitive lacquer called *photoresist.* The first photomask (B) is positioned over the wafer, and the disk is exposed to ultraviolet light. When the wafer is washed in special solvent, the photoresist washes away from the areas left exposed by the two rectangles in the photomask. A second bath in an etching acid dissolves the silicon dioxide layer beneath the two rectangles and exposes the silicon.

The next step is to change the electrical characteristics of the silicon beneath the two rectangles. This is done by deliberately adding an impurity or *dopant,* which in this case is boron. (C)

A traditional method is solid diffusion. The silicon wafers are inserted in a quartz rack inter-leaved with wafers of the appropriate dopant.

The rack is placed in a high temperature diffusion furnace, and atoms from the dopant migrate to the exposed surface of the silicon wafer. The photos on page 19 show NBS technician John Krawczyk loading a typical diffusion furnace.

Although diffusion furnaces such as this one are in common use, there are other ways of introducing impurities. One technique, now widely used in industry, involves firing a controlled beam of dopant ions into the crystal.

The rest of the production process basically repeats these steps.

A second photolithography step using another photomask, exposes the silicon between the two doped rectangles (D), and another treatment in the furnace forms a layer of silicon dioxide in this area (E). This will produce the "gate" of the transistor which acts as an electrically controlled switch.

A third photomask opens holes for electrical contacts through the oxide layer to the doped areas (F,G). An evaporation step covers the surface with a layer of aluminum metal (H). Finally, a photomask defines the interconnecting lines of the circuit and the excess metal is etched away leaving the finished pattern. (J).

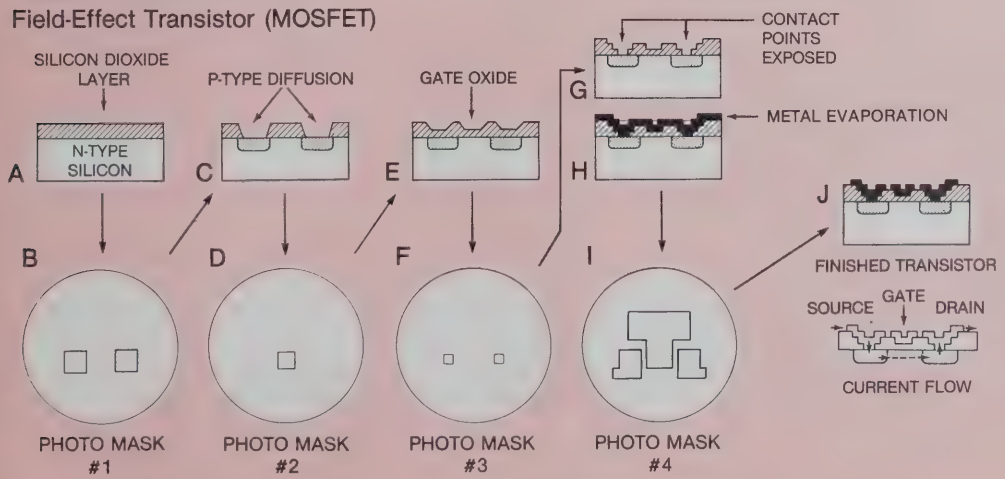
This is the final step for most test patterns constructed at NBS. To finish the process of producing actual circuits, a semiconductor manufacturer would inspect the wafer visually for obvious flaws, test it electrically with probes, and then the wafer would be scribed and broken into individual integrated circuit chips.

Wire leads are connected to each chip, usually by a machine that welds fine wires to contact points with a burst of ultrasonic energy. The chips are then packaged in a protective capsule. On page 19, Y. M. Liu, who manages the NBS semiconductor processing facility, is shown packaging a finished test pattern chip inside a glove box filled with inert nitrogen gas to protect the chip from contaminants such as moisture.

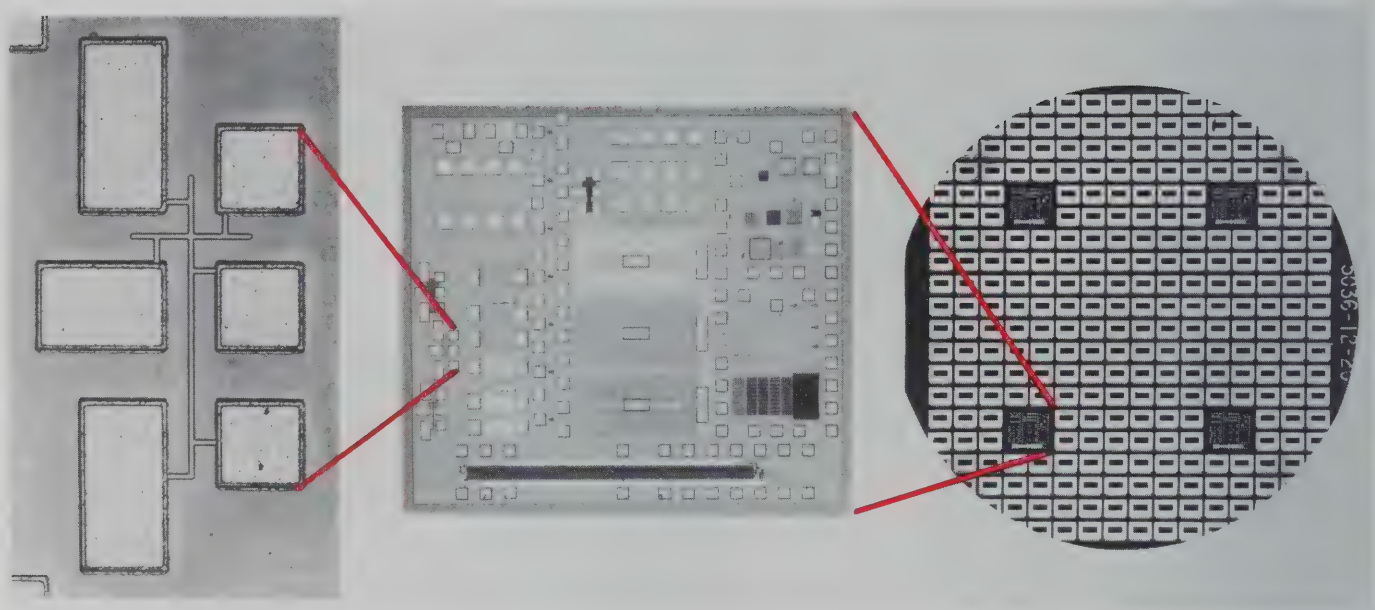
---

* *Letters in brackets refer to sketches in accompanying illustration.*

Metal-Oxide Semiconductor
Field-Effect Transistor (MOSFET)



The cross-bridge sheet resistor (left) is a test structure used to detect line width variations. It is part of a test pattern (center) including many other structures, which appears at regular intervals on the silicon wafer (right) used to make integrated circuits.



How important is quality control to semiconductor manufacturers? In 1976 a Lockheed official reported in the IEEE *Spectrum* that rejected semiconductor components from one supplier were running as high as 68 000 parts out of 106 000—64 percent rejections. Although this is a very unusual circumstance, even the average situation is far from ideal.

Test Patterns

An important concept in the quality control of semiconductor manufacture is the test pattern, an assembly of device-like test structures. Each structure within the pattern is designed to test specific aspects of the process used to build it. In photographs of silicon wafers covered with identical integrated circuit chips, the test patterns are usually easily spotted as small chips of a different design occurring at regular intervals across the wafer. Test patterns are processed along with the rest of the chips on an integrated circuit wafer and presumably any manufacturing faults which affect the circuits will affect the structures of the test pattern as well.

An example of an NBS test structure is the cross-bridge sheet resistor. (See photo, this page.) This particular test structure which takes the form of an elongated cross, appears on the photomask used to "print" a particular layer of the integrated circuit wafer. The cross-bridge sheet resistors are designed to test for variations in the line widths of the many conducting layers of the circuit.

Other test structures with varying degrees of complexity measure such factors as the alignment of different photomasks, the densities of dopants in the silicon, and electrical characteristics of the circuit elements.

You need measure only a few quantities to get all this information, according to Murray Bullis, head of the NBS Electron Devices Division. "We're measuring basically four things: voltage across two points, current, time, and length," he says. "We transform these data into physical parameters like sheet resistance (a measure of dopant concentration), defects in line width or alignment, profiles of dopants, and the like. Time is measured to give an idea as to how long the integrated circuit will hold a given electrical signal."

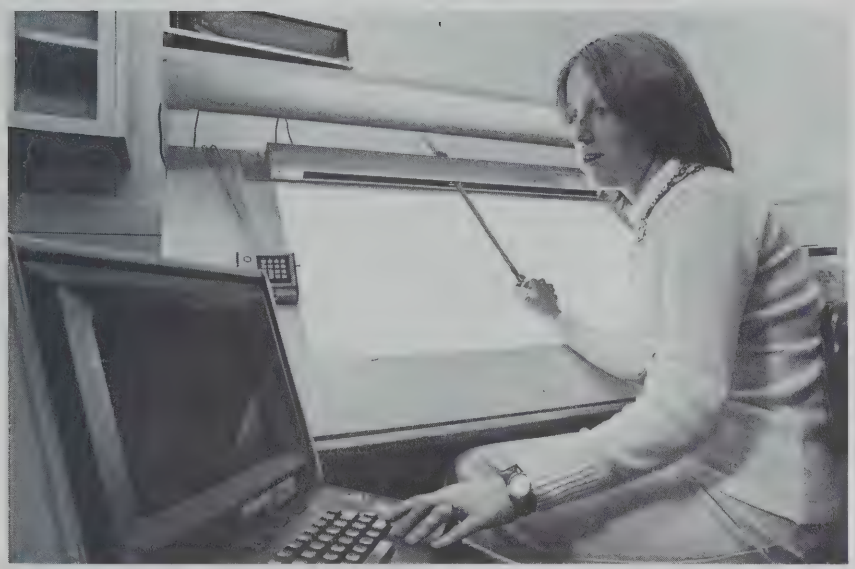
Panics and the PVW's

Test patterns in themselves are nothing new; most manufacturers use test patterns extensively during the initial design and production of new integrated circuits. Once production processes have been refined the number of test patterns made on each wafer is reduced to maximize the production of integrated circuits. From this stage on, the test patterns are often used only when a problem arises in the production process.

"Some people call these things 'panics'," says

Bottom. Kerry Fischer of the NBS semiconductor processing facility enters a test structure design into the computer memory.

Right. She uses a special drafting board which automatically converts the design to a set of coordinates in the computer.



Buehler, "because they're used only in a crisis situation."

The NBS group wants to encourage the use of test patterns and statistical analysis of test pattern data as part of a regular program to keep production processes "under control."

"You can reduce the problem to a need for uniformity," according to Bullis. "We're dealing with extremely complicated processes with many, many steps. It used to be that you could figure on taking a batch of production devices, taking a sample of the batch, and testing the sample to get the characteristics of all the devices.

"But now we're seeing increasing complexity. The number of individual elements in a given circuit is increasing, there are more functions per individual chip.

"What we have here is a very high technology field that is entering a stage that pushes the materials and processes involved further than ever before. Make things smaller, make them perform more functions. We have to have a measurement technology that can probe the limits of these processes—and tell us when they've been reached." Bullis concludes.

"Test patterns are going to become more and more important in the future," agrees Gary Carver, a physicist in Bullis' division. Many large semiconductor companies have process engineers who work a lot by intuition, he says. "But when they start producing circuits with Very Large-Scale Integration,* they're not going to be able to get away with that."

The NBS approach to integrated circuit process control rests on two ideas: the use of test structures that isolate particular factors in the production process (line widths, dopant concentrations), and the use of high speed electronics and statistical analysis to make the best possible use of the data obtained from the test structures.

The second of these two ideas depends on the use of "process validation wafers" or PVW's. A PVW is a complete wafer that holds nothing but test pattern chips. The same test pattern is repeated across the whole wafer in the same way that integrated circuits are made. To see how this works, consider a typical test pattern that might be found on a PVW.

Microelectronic test pattern NBS-7 is an experimental pattern designed for production lines that make TTL (transistor-transistor logic) integrated circuits which are used in many computers and digital instruments. Some of the things tested by NBS-7 are variables in the production process, such as the electrical resistance of each circuit layer or

** There is no precise definition for Very Large-Scale Integration (VLSI), but in general it means a circuit with upwards of 100 000 transistors.*

turn page

NBS technician Louie Robinson holds a polishing disk with six wafers mounted on it.

A special circular saw cuts the silicon crystal into flat, round "wafers."

the alignment and resolution of the photomasks. The pattern also includes several NAND* gates to provide a link between the characteristics of the test structure and those of the circuit elements, as well as structures to test for "random faults" that can lower the total number of "saleable" circuits.

The PVW is treated in the production process as if it were a production wafer. The appropriate photomasks are prepared, and the PVW is made using the same equipment and procedures as in making any other wafer. The advantage of this system is that the data gathered from all the test patterns on the PVW can be used to assemble a detailed "map" of selected factors over the entire wafer, something that can't be done accurately with a handful of test patterns on a production wafer.

The wafer map shown on page 14 was made from a PVW covered with NBS-7 test patterns. The map depicts the electrical resistance of a layer of the wafer which forms part of the PVW transistors. The map shows a pattern of lighter and darker areas which represent lower and higher values of resistance.

A similar map shows the gain of the transistors on that same PVW. (Gain, a measure of the transistors' ability to amplify a signal, is an important factor in the performance of the circuit.) In this map darker areas correspond with higher gain. Notice that the transistor gain follows roughly the same pattern as the resistance of that one particular layer.

For the process engineer, this means that out of a number of factors that could affect the gain of transistors in this type of circuit, the one to watch is the resistance of that layer. By controlling the resistance through variations in dopant densities or other measures, the engineer can also have control over the gain of the transistors.

The PVW concept, according to the NBS researchers, offers several advantages over more traditional ways to use test structures. In the first place, it provides much more comprehensive data. It does so cheaply, and without disrupting the production process. The PVW "maps" can be used to diagnose production problems quickly without wasting money producing unusable circuits. If it becomes necessary to change the test pattern, a new PVW can be designed without changing the photomasks used for production wafers.

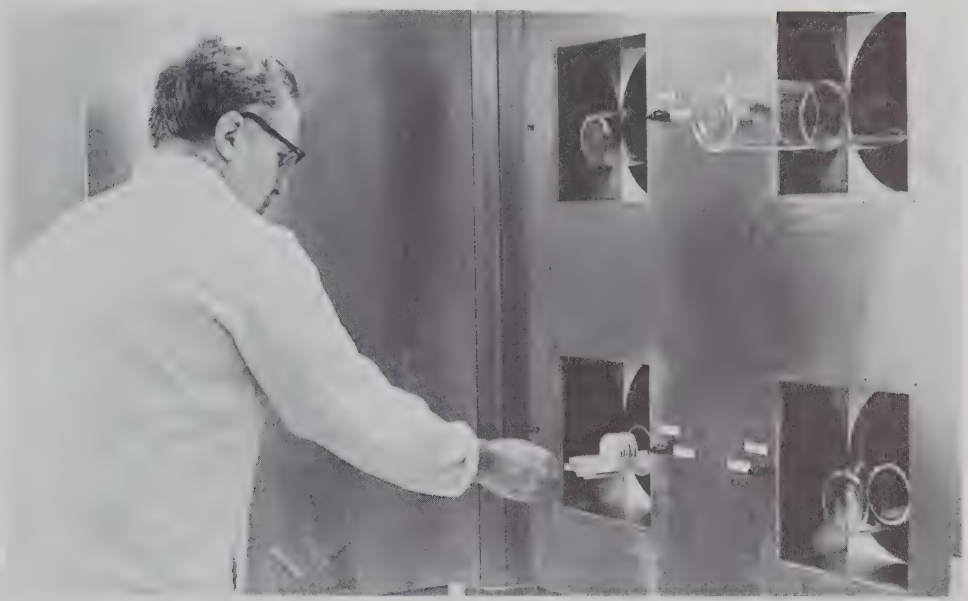
But the PVW's greatest potential, says Buehler, may lie in assuring quality control when integrated circuits are bought and sold. How is a customer interested in buying several thousand integrated circuits to know how reliable a manufacturer's product is, particularly when several of the processes involved may be trade secrets? In most cases a PVW can be designed and certified to test all the factors of interest to the customer with minimum knowledge of the manufacturer's operation.

Documented Structures

Regardless of the type of testing used by integrated circuit manufacturers, NBS can often provide

** A NAND, for "Not-And," gate consists of several transistors and other circuit elements.*

Left. To change the electrical resistance of the silicon, wafers are inserted in a quartz rack and inter-leaved with wafers of the appropriate dopant. Below. The wafers are heated, causing the atoms from the dopant to migrate to the silicon. NBS technician John Krawczyk loads a special high temperature diffusion furnace.



information or services to help make their quality control procedures easier and more efficient.

A large part of the NBS effort in this area is devoted to providing carefully documented information on specific test structures to interested users. This information is distributed through reports and conferences and can be adapted by manufacturers to suit their individual needs.

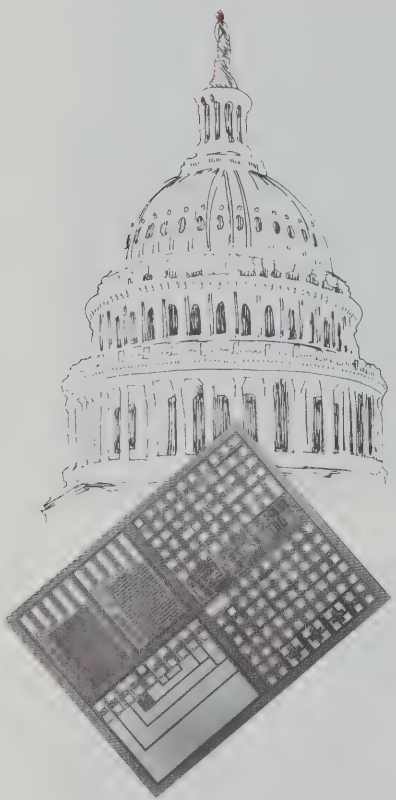
The manufacturers who use this information include a number of organizations other than commercial semiconductor suppliers. Companies that manufacture automobiles, aircraft, computers, cameras and electronic instruments, as well as universities and government laboratories, are all interested in the use of test structures for process control. NBS has already supplied its test structures to over 60 such organizations.

In addition, NBS provides the designs for complete test patterns. Four of these are currently available to the general public. Test patterns NBS-2, NBS-3, and NBS-4 provide tests of transistor gain, electrical resistivity of various layers, dopant density and bulk resistivity. Test pattern NBS-15 provides tests for alignment between masking levels. The first three patterns can be obtained in the form of photomask sets, while the fourth is made available in the form of test structure coordinates recorded on magnetic tape.

For information on these and other facets of NBS work on semiconductor measurement technology, contact the Electron Devices Division, National Bureau of Standards, Washington, D.C. 20234, 301/921-3786. □

Y.M. Liu, manager of the NBS semiconductor processing facility, packages a finished test pattern chip inside a glove box filled with inert nitrogen. The package protects the chip from moisture and other contaminants.

turn page



The Semiconductor Industry and the Federal Government

by Murray Bullis

In the early days of the integrated circuit, the U.S. semiconductor industry benefited significantly from interactions with the Federal Government, especially in the areas of defense and space science. At key times in the development of the industry the Federal Government provided support for research and development, for the procurement of devices, and for the establishment of manufacturing capability. In addition, Federal educational policies served to increase the number of scientists and engineers trained in this field.

More recent Federal policies and actions have tended to reduce both the level of direct support and the incentives for private sector investment in this industry. At the same time, intense competition from foreign producers and major foreign government-financed programs to advance integrated circuit technology, especially in Japan, threaten the U.S. technological lead in semiconductors and integrated circuits.

In addition, basic changes in the nature and capital requirements of the industry are occurring.

The costs of both circuit design and production equipment are rising rapidly as circuit complexity increases; as a result, it is becoming much more expensive to initiate new processes, to introduce new products, to establish new companies, to tolerate mistakes in product design, or to test for flaws in design or manufacture. At the same time, Defense Department requirements for semiconductor components, as a fraction of the total market, are diminishing, and the technology is being driven predominantly by high-volume applications.

Many in the industry believe these factors require responsive action by the Federal Government. Clearly the industry favors changes of Federal policies in areas such as regulation, taxes, tariffs and other trade barriers, and export controls. There is also a broad consensus in the industry that, even despite the great technological success of semiconductor manufacturers, further Federal activity is needed in technological areas as well, especially areas such as basic data, physical principles, test methods, and associated techniques, quality control, and manufacturing equipment, which are of a generic nature and applicable throughout the industry.

During the past decade, NBS has played a key role in providing essential measurement technology to the semiconductor device industry and to the broader communities of suppliers of materials and equipment to this industry and of users of semiconductor devices, including Federal agencies. More recently, several new programs related to semiconductor devices and integrated circuits are being considered or have recently been initiated by a number of Federal agencies. These include the National Science Foundation Microstructures Engineering Program, the Department of Energy university-industry collaborative program to broaden the information base for photovoltaic solar cells, the Department of Defense Very High Speed Integrated Circuits Program, and the Department of Commerce Cooperative Technology Program. Several departments also have well-established programs which conduct or support research and development on semiconductor materials and devices.

The optimum mix of these various programs, new and old, from the standpoint of national economic health and the health of the U.S. semiconductor industry, has not yet been established. Federal and industry leaders are now discussing the options in hopes of finding the appropriate balance.

Bullis is chief of the NBS Electron Devices Division.

SCIENCE ON SAFETY'S SIDE~

Methods for Helping Keep a Child's World Safe

by Susan Lieberman

A three-year-old boy grins with joy while cruising the neighborhood on three wheels. The next moment his face contorts with the pain of a scraped knee and a bruised elbow. A seven-year-old girl attacks the schoolyard jungle gym with all the zeal she can muster. Moments later, tears stream from the pounding hurt of a bumped head.

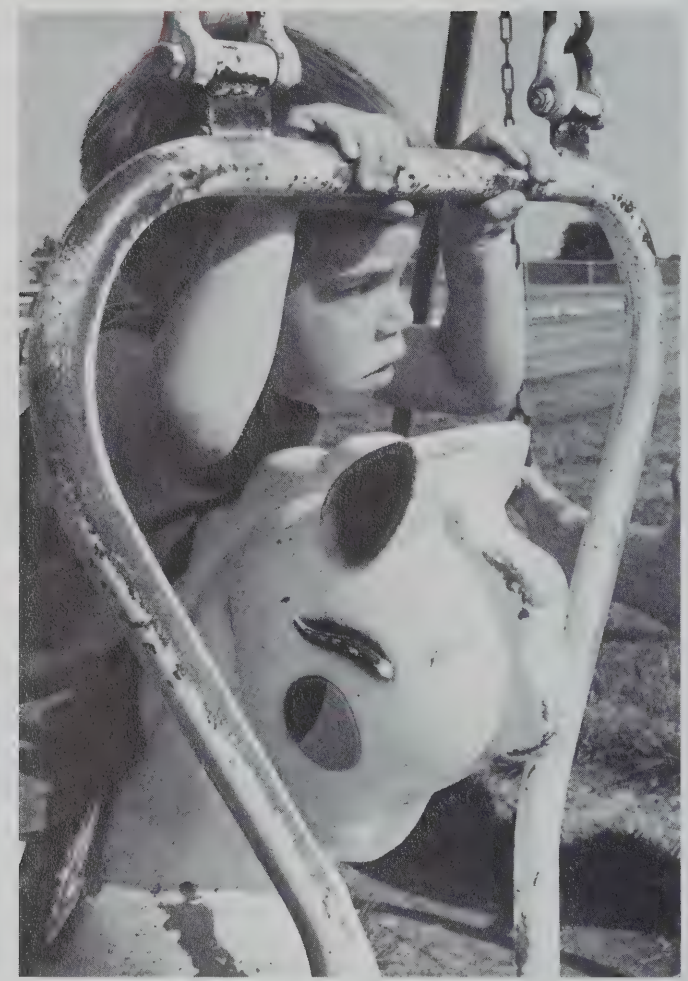
Growing up is often an unavoidably painful experience. Still there is something that can be done to soften the pain and prevent some of the tragedies of childhood accidents. At NBS, researchers are working to improve the safety of products with which children come in contact. By developing methods to test the safety and performance of toys, sporting equipment, and household wares, they hope to encourage the use of safer, more durable product designs.

One of the most common settings for childhood injuries is the playground. At the request of the National Association of Children's Home Playground

---

Lieberman is a writer and public information specialist in the Public Information Division.

turn page



Manufacturers, Inc., in 1976, NBS developed a Voluntary Product Standard (VPS) (See box.) for equipment such as swing sets, jungle gyms and merry-go-rounds. The standard delineates safety requirements for these products by proscribing harmful levels of paint toxicity or the presence of sharp edges, points, and other dangerous surfaces and through recommendations for structural integrity, safe spacing of the equipment, and other features.

But the majority of playground-related injuries occur when children fall from equipment. About half of these accidents produce head injuries, ranging in severity from minor scalp bruises to skull fractures, concussions, and death. The material (if any) used to cover the ground beneath the equipment influences the severity of these injuries. Until recently, information has been scarce on the amount of protection provided by various materials.

In February, NBS published a report which describes a new test method for examining playground surfaces.* During the research to develop this test, the investigators found significant differences in the amount of protection provided against head injuries by the various surfacing materials.

**For a copy of the report, send $5.25 to the National Technical Information Service, Springfield, Virginia 22161. Use number PB 292 743 when ordering.*

What is a VPS?

Voluntary product standards are consensus agreements reached by producers, distributors, users, consumers, and other interested groups according to procedures established by the Department of Commerce. The purpose of these standards is to establish nationally recognized requirements for products that assure acceptable levels of product quality and safety.

NBS assists in the standards development process by acting as a coordinator, providing technical assistance including the assurance that the standard is technically sound and that it complies with the criteria of the Department of Commerce Voluntary Standards Program.

The use of a voluntary product standard is just that—voluntary. As is true for all other Bureau programs, NBS has no regulatory power to enforce a standard's provisions. However, since the standards represent a consensus of all participating groups, their provisions could become trade customs. In addition, should the standard be made a part of such legal documents as sales contracts or codes, the parties concerned may enforce compliance with the code.

Voluntary product standards benefit both the producer and the consumer by assuring specific product quality requirements. Producers and distributors whose products satisfy the requirements of a voluntary product standard, may refer to the standard in advertising and on labels to promote greater public confidence in their products.

For copies of the voluntary product standards procedures or for more information about these standards contact the Office of Standards Information, Analysis and Development, A168 Technology Bldg., National Bureau of Standards, Washington, D.C. 20234, 301/921-2356.

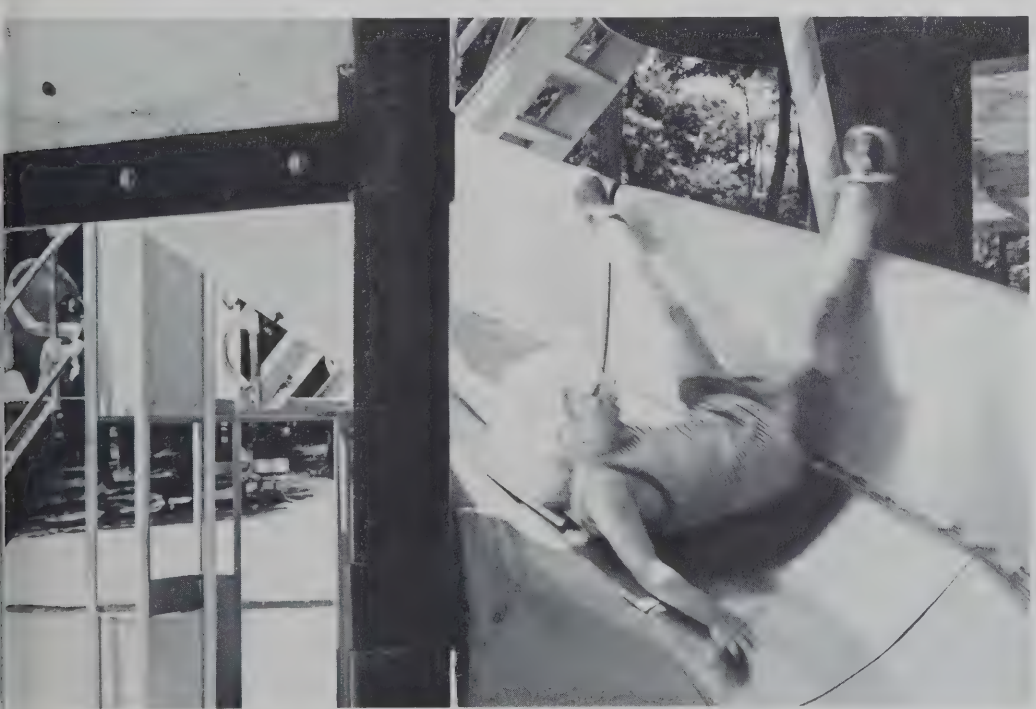
The Bureau's study, which was sponsored by the Consumer Product Safety Commission (CPSC), determined that loose materials, such as pine bark nuggets, blue stone dust, sand, shredded tires, and shredded hardwood bark appear to be the safest materials for use under playground equipment.

However, even though these loose materials performed better than solid materials such as rubber mats or synthetic turf, the study pointed out that they require regular maintenance to insure continued effectiveness. For example, running and jumping activities may alter the thickness of the materials, downgrading the level of protection.

The test method measures a material's ability to lessen the severity of an impact. An instrumented headform is dropped onto a sample of playground surfacing material and the resulting impact on the headform is measured. NBS researchers recommend a minimum level of protection, or impact attenuation, based on related earlier studies and scientific literature; this should prevent most serious head injuries.

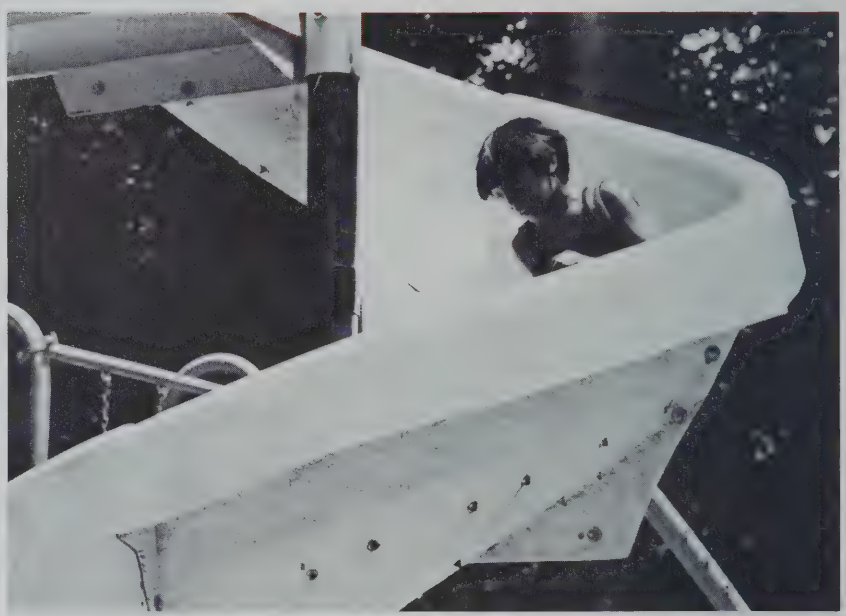
Earlier Research

The NBS work on product safety, especially that related to children, started at least as early as 1957 when Congress asked the Bureau to develop standards for refrigerators. Up to that time, about a dozen



turn page

The majority of playground-related injuries occur when children fall from equipment. The material used to cover the ground beneath the equipment influences the severity of these injuries.



children died each year of suffocation after becoming trapped in old, abandoned refrigerators.

After studying children's strength and their reactions to simulated entrapment, NBS recommended a standard requiring that hook-type closures be replaced with magnetic latches. The magnetic latches on today's refrigerator doors have virtually eliminated the entrapment of young children, and have improved the functional performance of the appliance as well.

In another Bureau project dealing with children's strength, researchers examined the push, pull, twist, and squeeze strength of children aged two to six. With the knowledge gained from this study, NBS and manufacturers have been able to take child strength into account when developing standards and products. For example, another DOC Voluntary Product Standard developed by NBS at the request of the Toy Manufacturers of America includes guidelines for insuring the safety of toys through tests of material quality and the strength of strings and elastics. Also included in that standard are limits on the use of sharp edges and points and on the force produced by projectiles from toys such as dart guns.

The problem of eye injuries from toy projectiles warranted separate attention. Bob Berger, a biomechanical engineer for the NBS Center for Consumer Product Technology (CCPT), has developed a test method and recommended pass-fail criteria to determine whether or not a particular toy is safe. The test involves firing darts or other missiles from toy guns and similar playthings into a special pad in order to measure the force of impact and the rate at which the force is applied. The faster the force of the projectile is applied, the more dangerous the toy.

Berger's work entailed development of a mathematical model and experiments with a surrogate eyeball made out of rubber, which reacts much as a real eye would. "We do a lot of research with human subjects to find out how people interact with their products, but we can't allow volunteers to expose themselves to injury," explained Walter Leight, chief of the Product Safety Engineering Division of CCPT. Instead, surrogate devices are developed to simulate body parts and functions.

In addition to the rubber eyeball, CCPT uses teflon "skin" to test sharp edges and instrumented headforms for impact testing. Besides the playground surface materials research, the headforms are also used to establish test methods and safety criteria for protective headgear, such as football

helmets. The test methods are designed to measure the amount of impact energy that is absorbed by the helmets.

In these tests, a helmeted headform, mounted on a monorail, is dropped—this time onto an anvil. At the moment of impact, the response of the headform—measured by linear acceleration and "neck" rotation—is displayed on an oscilloscope. As the protection provided by the headgear increases, values for linear acceleration and rotation are expected to decrease. The next step, according to Leight, is to determine the effects of wear and aging on the protective characteristics of the equipment.

"What happens to a football helmet after 10 impacts? After 100? If a kid leaves the helmet in the rain, or sits on it, is it just as good as new in terms of protection? We're going to set up accelerated aging tests to find out how environment or use degrades safety," explained Leight. "We also want to know which parts and materials are most likely to be affected."

Another product that will be examined for its effectiveness over time is the reflective tape designed to make bicycles more visible. CCPT is devising tests to determine how well various types of reflective tape stay on and remain conspicuous even when scuffed in normal use.

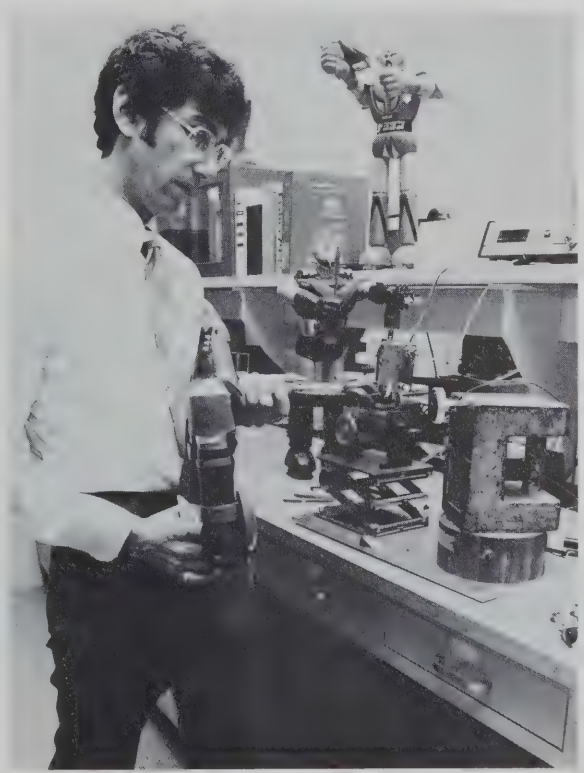
After determining the importance of wear and aging on safety—for football helmets, reflective tape, and other products—NBS will be able to recommend appropriate conditioning and testing procedures to CPSC. This will also lead to methods for estimating the useful safe life of these products.

"For a long time we've emphasized product performance," said Stanley Warshaw, Director of CCPT. "Now we are interested in emphasizing the safety of consumer products, especially those with which children come in contact. And that means building a data base of research to help predict how and where and why accidents occur."

Crucial to the success of these safety and performance standards is some measurement of the potential impact on manufacturers and the public. Does the standard lead to safer products, thereby lowering the number of product-related injuries? What are the costs of compliance? Can the standard be implemented by manufacturers, especially small businesses?

Answers to these questions and more information on contributions of product failures to accidents should lead to better standards, product improvements, and guidance for parents to help keep a child's world safe. □

Nick Calvano works on a test method to measure the amount of protection a helmet provides its wearer.



Robert Berger fires a toy robot into a test pad to measure the force of impact and the rate at which the force is applied.

STAFF REPORTS

NEUTRON RADIOGRAPHY OF CARDIAC PACEMAKER BATTERIES

In a project funded by the Food and Drug Administration, scientists at the National Bureau of Standards are investigating one of the phenomena which occurs as cardiac pacemaker batteries lose power. Current batteries must be surgically removed and replaced every 3 to 5 years. The goal of the manufacturer participating in this study is to develop a battery that would power a pacemaker for 15 years.

Donald Garrett, Reactor Radiation Division, A108 Reactor Building, 301/921-3634.

Studies are being conducted by the NBS Neutron Radiography Group to determine the behavioral characteristics of the electrolyte in lithium iodine cardiac pacemaker batteries as a function of battery rundown.

These new batteries consist of two central anodes of lithium metal with a cathode on either side as shown in Figure 1. The space between the anode and electrodes is filled with polyvinyl puridine doped with iodine. As lithium iodide is formed, an electropotential is produced between the anodes and electrodes which is employed to power the cardiac pacemaker.

With the use of x-radiography techniques, it was possible to penetrate the stainless steel case and electrodes to visualize only the "high atomic number components in the electrolyte such as iodine. Thermal neutrons, on the other hand, can more easily penetrate heavy materials such as steel and yet are easily absorbed or scattered by light materials in the electrolyte such as the hydrogen contained in polyvinyl puridine.

Initial neutron radiography conducted on a new battery revealed the electrolyte distribution illustrated in Figure 2. Further neutron radiography on a battery, which had been run down on an accelerated basis to 105 percent of its projected lifetime, exhibited what appeared to be areas of high neutron transmission shown as dark areas in Figure 3.

In an attempt to better understand the observed phenomenon, three-dimensional neutron laminagraphy was performed on the battery. This technique was first used with neutrons rather than x-rays at the Argonne National Laboratory and was later further developed at NBS. Its primary use is to visualize the details of complex objects in three dimensions. In this case, the technique allowed examination of the electrolyte in layers spaced at 0.050-in (1.27-mm) increments.

Neutron laminagraphy radiographs revealed that areas of high neutron transmission occurred at various depths in the electrolyte as shown in figures 4 through 6.

Several phenomena could be taking place with battery rundown. Two possible explanations are void formation or selective elemental depletion in the electrolyte. These however are only preliminary suggestions. Further experimentation and comparison of neutron and x-radiographic data and destructive analysis of the battery must be carried out. Accordingly, the next step in this project will be to cool the battery to low temperatures, freezing the electrolyte and slice it into 0.5-inch (1.27-mm) layers. Visual observations of the battery layers can then be compared with the radiographs for correlation studies, in an attempt to explain the chemical kinetics taking place.

Figure 1—*Schematic diagram of a cardiac pacemaker battery.*

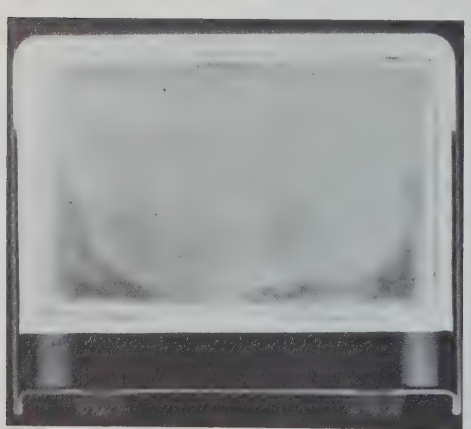
Figure 2—*Neutron radiograph of undepleted cardiac pacemaker battery utilizing standard radiograph techniques.*

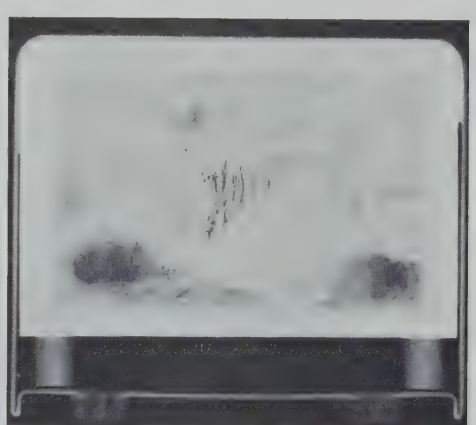
Figure 3—*Radiograph of battery depleted to 68 percent of rated lifetime.*

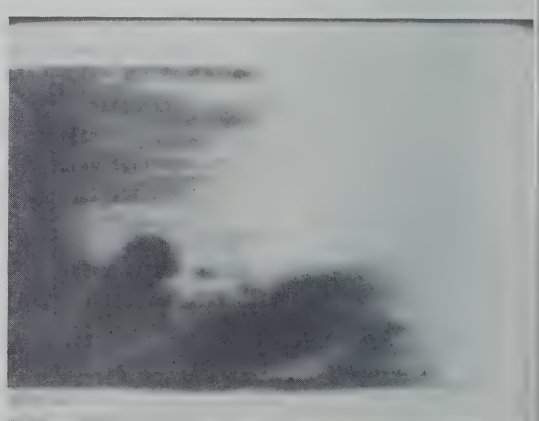
Figure 4—*Laminagraph taken at 0.15 inches (3.81 mm) below surface of battery.*

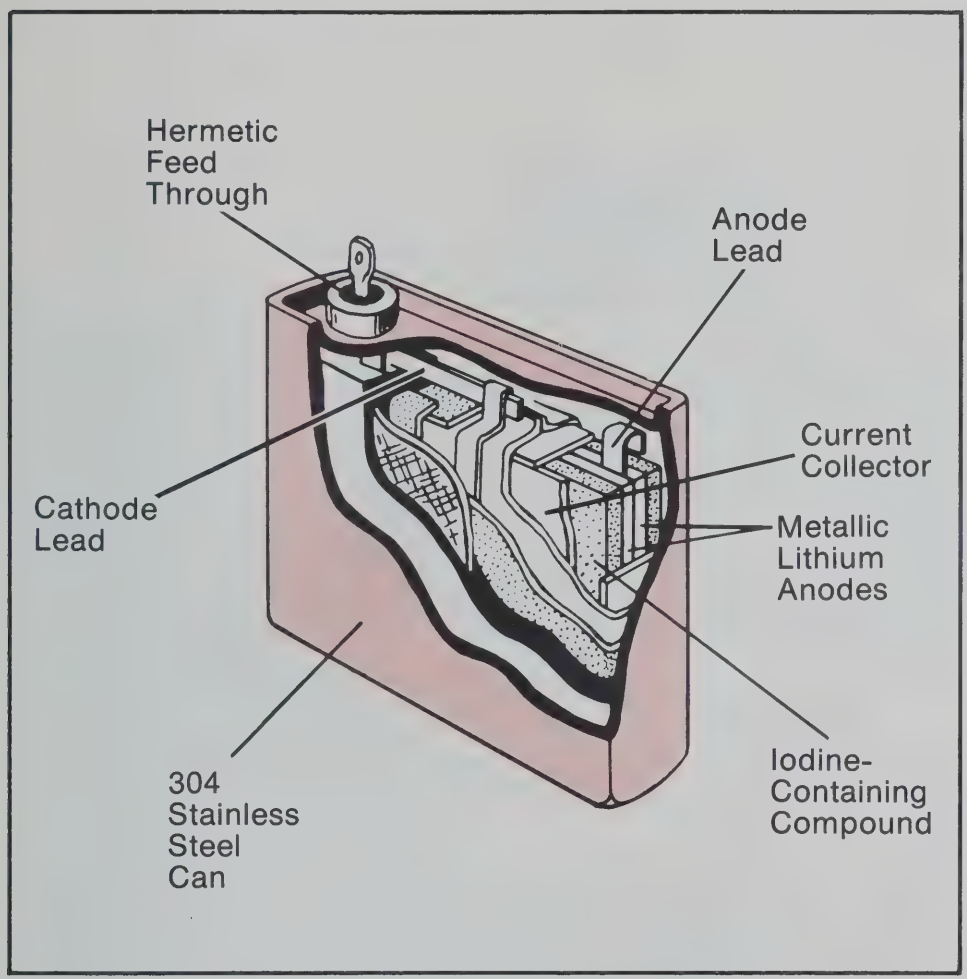
Figure 5—*Laminagraph taken at 0.25 inches (6.35 mm) below surface.*

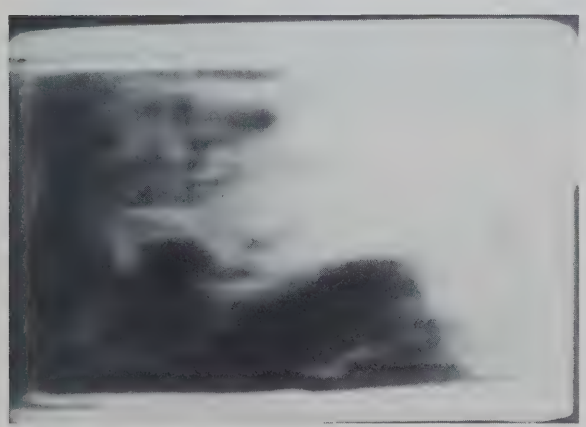
Figure 6—*Laminagraph taken at 0.43 inches (11.43 mm) below surface.*








Hermetic
Feed
Through
Anode
Lead
Current
Collector
Cathode
Lead
Metallic
Lithium
Anodes
304
Stainless
Steel
Can
Iodine-
Containing
Compound



turn page

THE NETWORK MEASUREMENT INSTRUMENT

A microprocessor-based instrument designed at the National Bureau of Standards enables users to measure directly the quality of service delivered by a computer network. The portable measurement instrument provides more comprehensive data than a minicomputer system developed to perform the same general functions.

Marshall D. Abrams, Systems and Network Architecture Division, B226 Technology Building, 301/921-3517.

The Network Measurement Instrument (NMI) shown in front of the Network Measurement Machine (NMM), was developed to enlarge on the capabilities of the NMM, while decreasing the physical size of data collection and processing equipment.

The NMI provides a new method for implementing the Network Measurement System (NMS)* which is based on the concept that a user is more interested in the quality of work performed by a network service and its cost than in the more traditional measures of internal system efficiency. Two basic network performance characteristics of concern to the user are measured: *response time*, which is the elapsed time from the last user keystroke until the first meaningful system character is displayed at the user's terminal; and *turnabout time*, which is the elapsed time from beginning to end of a specified sequence of operations.

An earlier system for implementing the NMS developed by NBS uses the NMM to collect measurement data and a Data Analysis Package (DAP) to produce reports. The NMM includes disk and magnetic tape storage, two programmable clocks, and data communications interfaces. An automatic calling unit and line selector (ACU/LS) and a specially designed communications line interconnections device called a "data probe" connects the NMM to the network to be measured.

* See the June 1978 issue of DIMENSIONS/NBS, pp. 22-23.

Figure 1—*Network Measurement Instrument (NMI) in front of the Network Measurement Machine (NMM).*

Data collected by the NMM is recorded on tape for later analysis by the DAP, which runs on a large time-sharing computer and generates reports about delivered network services, user demands, and network utilization.

The Network Measurement Instrument (NMI)

The NMI collects measurement data, calculates derived measurements, applies statistical analysis techniques to both the measured and derived data, and generates percentile statistics and histogram reports for the measurements. It provides a direct view display of the analysis of data as well as hard copies of the reports. The NMI also goes beyond the NMM in its ability to measure character and bit-oriented synchronous data communications.

The NMI architecture (figure 2) is based on a system organization that partitions functions among three microprocessors. Each microprocessor is tailored for a specific function by general and special purpose subsystems.

The *communications processor* acti-

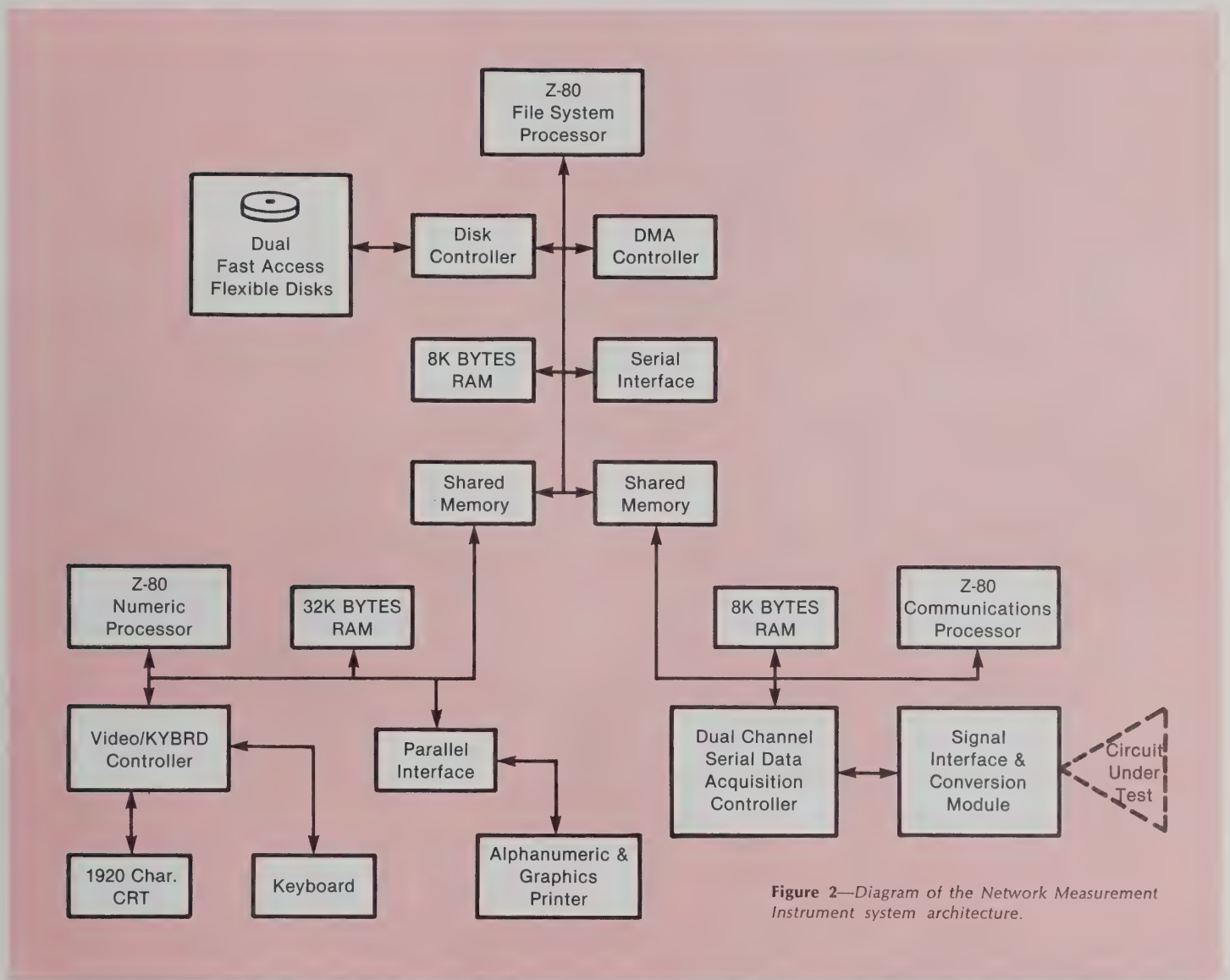


Figure 2—*Diagram of the Network Measurement Instrument system architecture.*

vates the Serial Data Acquisition Controller which monitors data transfers on the circuit under test, correlates those transfers to a real-time clock and performs the measurement tasks. This processor forwards measurement data to neighbor processors for additional analysis prior to storage in the file system processor.

The *file system processor* manages the file of measurement data as well as measurement programs and data reduction programs. It includes a mass storage subsystem that uses fast access flexible disks. Random access to data on the disks takes as little as 33 ms.

The *numeric processor* carries out data reduction programs and produces summaries of traffic statistics describing the nature of data transmission on the circuit under test during the measurement period. This processor handles operator communications from the system console and interfaces the printer that produces permanent copy of the measurement results. It also provides softcopy on the 1920 character CRT terminal.

Interfaces

The NMI connects to standard interfaces between data circuit terminating equipment and data terminal equipment. The cable between these components can be unplugged and the NMI inserted. The NMI does not affect signal quality.

Data Collection and Processing

Data is collected in accordance with a Stimulus - Acknowledgement - Response

turn page

model developed by NBS to characterize interactive computer utilization. The stimulus phase is the input from the operator to the network. In asynchronous communication, the receipt of a line feed advancing the terminal carriage is considered an acknowledgement of the stimulus, not a meaningful response. In synchronous communication the acknowledgement state may not be apparent to the user but must be recognized by the NMI. The response is the output from the network beginning with the first meaningful character.

From measurements of stimulus-acknowledgement-response delay times, transmit times and character counts, the NMI calculates the transmission rates, response and transaction times, and applies statistical techniques to reduce the large number of observations obtained. Percentile statistics and histograms on the measured data are processed and produced on hard or soft copy.

The NMI is an innovative approach to the measurement of interactive computer network services. Prototype equipment manufactured by a contractor is being tested. Following demonstration of satisfactory performance, this instrument will be available for application in measuring and evaluating computer network services.

MOLYBDENUM TEMPERATURE STANDARD REFERENCE MATERIAL

Molybdenum as a high-temperature enthalpy and heat-capacity Standard Reference Material in the temperature range 273.15 to 2800 K can be obtained from the National Bureau of Standards Office of Standard Reference Materials.

The certified, smoothed enthalpy and heat-capacity values of Standard Reference Material 781, Molybdenum, were derived principally from enthalpy measurements with two different types of receiving calorimeters in the temperature range 273.15 to 2100 K and from heat-capacity measurements which employed a high-speed, millisecond-resolution pulse technique in the temperature range 1500 to 2800 K. The estimated overall inaccuracy in the tabulated values of heat capacity is ±0.5 percent at the lower end of the temperature range and increases to no more than ± 3 percent at 2800 K.

Molybdenum as a high-temperature calorimetric standard represents a significant extension of the temperature range beyond that covered by the existing NBS SRM 720, Synthetic Sapphire (Al_2O_3). In addition, molybdenum offers the advantages of metallic electrical conductivity, machinability, and availability in the form of rods. This makes it especially valuable for applications in high-speed, pulse-type thermophysical measurements using resistive self-heating and in other methods in which several thermal properties are measured simultaneously.

This SRM is available in the form of rods of two sizes and may be ordered from the Office of Standard Reference Materials, B311 Chemistry Building, National Bureau of Standards, Washington, D.C. 20234.

The prices and sizes available are:

SRM	Diameter (cm)	(cm) Length	Prices
781-D1	0.32	10	$ 76
781-D2	0.64	10	$118

Longer multiple lengths may be obtained by special order.

TWO TOTAL PROTEIN STANDARDS AVAILABLE

The National Bureau of Standards Office of Standard Reference Materials has available two SRM's for use in determining total serum protein.

Standard Reference Material (SRM) 926, Bovine Serum Albumin (lyophilized powder), and SRM 927, Bovine Serum Albumin (7 percent solution) are intended primarily for calibration and standardization of protein analyses, for routine evaluation of daily working standards used in these procedures, and for use also by manufacturers of working clinical standards and kits to assure the quality of these products. Both SRM's conform to the specifications of the National Committee for Clinical Laboratory Standards as set forth in Approved Standard: ACC-1, Standardized Protein Solution (Bovine Serum Albumin).

Bovine albumin in powered form (SRM 926) is supplied for investigators who require well-characterized, pure polypeptide material with certified values for constituents such as ash, carbohydrate, non-protein amino compounds, water and lipid as well as data concerning amino acid composition, spectral properties, electrophoretic characterization, refractive index increment, mass density, partial specific volume, molecular weight, nitrogen analysis and fatty acid composition of included lipid.

The 70.45 g/L albumin solution (SRM 927) is supplied in vials containing sufficient volume to allow withdrawal of two-1 mL aliquots to be used in protein assays, such as the biuret technique. The vialed solution is intended to be used within one day and in no case is storage recommended once in a vial is opened. Stability tests conducted at NBS on equivalent samples indicate that, in the unopened containers, the material will remain stable for a period of three years.

Bovine serum albumin (Lyophilized powder), SRM 926, is issued in 5-gram quantities in sealed vials. The price of SRM 926 is $203. Bovine serum albumin (7-percent solution), SRM 927, is issued in units of 10 vials, each containing 2.15 mL of solution. The price of SRM 927 is $122. These Standard Reference Materials may be ordered from the Office of Standard Reference Materials, B311 Chemistry Building, National Bureau of Standards, Washington, D.C. 20234.

CONFERENCES

For general information on NBS conferences, contact JoAnn Lorden, NBS Public Information Division, Washington, D.C. 20234, 301/921-2721.

COMPUTER NETWORKING SYMPOSIUM

The 1979 Computer Networking Symposium, will be held at the National Bureau of Standards in Gaithersburg, Maryland, on December 12. The meeting is sponsored by the NBS Institute for Computer Sciences and Technology (ICST) and the Computer Society Technical Committee on Computer Communications, Institute of Electrical and Electronics Engineers (IEEE).

The following topics will be discussed:

—analysis techniques
—applications
—architecture
—authentication techniques
—communication networks
—design techniques
—distributed data bases
—economics of networks
—encryption techniques
—interfaces
—interoperability
—interprocess communications
—local data networks
—measurement
—modeling and simulation
—network security
—processor security
—protocols
—reliability
—requirements specification
—satellite communications
—standards
—survivability

For further information, contact Fran Nielsen, B212 Technology Building, 301/921-2601.

PROPERTIES OF MATERIALS CONFERENCE

The Basic Optical Properties of Materials conference will be held May 5-7, 1980, at the National Bureau of Standards in Gaithersburg, Maryland.

The purpose of the conference is to discuss the state of the art in the measurement of the optical properties of optical materials for advanced applications. The emphasis will be primarily on materials properties rather than on optical devices, although papers on optical devices might be included if they provide new insight concerning the underlying physical processes. The primary focus of the conference will be on the measurement and theory of basic optical properties of materials in bulk, thin film, and fiber form. Areas to be covered could include:

—refractive index and index distribution
—absorption
—response to external stimuli—thermo-optics, piezo-optics, electro-optics, magneto-optics
—experimental methods—ellipsometry, calorimetry, photo-acoustic spectroscopy, reflection, internal reflection, and guided wave techniques
—fundamental nonlinear optical parameters—nonlinear indexes and nonlinear absorption coefficients
—physical mechanisms underlying basic optical properties
—optical properties for novel applications—plastics, laser glasses, graded index materials, optical fibers

Call for Contributed Papers

The conference will contain both invited and contributed papers. A number of contributed papers covering original unpublished work on the meeting subjects will be accepted for presentation. Potential contributors should reply as soon as possible, so that detailed instructions and appropriate manuscript paper can be sent to each author. Each author will be expected to submit the following material on the paper supplied:

—A 25-word abstract of the paper for the meeting program.

—A summary of the presentation. This summary of up to four pages will be reproduced directly by photo-offset from the material submitted by the author.

Summaries of all accepted papers will be printed as submitted in a Digest of the meeting which will act in lieu of a conference proceedings. The Digest is to be distributed at the conference.

Completed abstracts and summaries must reach the National Bureau of Standards by January 7, 1980. Authors will be notified whether papers have been accepted by February 15, 1980.

For further information contact: Kathy Stang, B348 Materials Building, NBS Washington, D.C. 20234, 301/921-2835.

LIFE-CYCLE COST ENERGY WORKSHOPS

New mandatory requirements for life-cycle cost analysis that must be made by all Federal agencies in evaluating energy conservation and solar energy projects will be explained in a series of upcoming regional workshops. The workshops are being sponsored by the Department of Energy (DOE) and conducted by the National Bureau of Standards.

The new life-cycle cost requirements—which will apply to all new and existing Federally owned and leased facilities—were mandated by the National Energy Conservation Policy Act of November 1978 and an earlier Executive Order issued by President Carter. They are part of a Federal effort to achieve substantial reductions in Federal energy use by 1985. The proposed life-cycle cost methods and procedures, published in the April 30

issue of the *Federal Register*, are expected to be finalized in the near future. They are being established by DOE, with technical assistance provided by NBS.

The workshops are aimed at a cross section of individuals who will need to know the details of life-cycle costing methodology: manager of Federal facilities who are responsible for implementing energy conservation programs; analysts who will perform the evaluations; and architects, engineers, builders, and energy specialists in both the public and private sectors who require a working knowledge of the mandated procedures.

Regional workshops will be held October 25-26 in New York; November 12-13 in Chicago; November 19-20 in Dallas; December 11-12 in Atlanta. For more information about workshop schedules and registration, contact Rosalie Ruegg, Center for Building Technology, Building Research A319, NBS, Washington, D.C. 20234, or Jack Vitullo, Federal Program Office, Office of Conservation and Solar Applications, Department of Energy, Room 3133, 20 Massachusetts Ave., N.W., Washington, D.C. 20585.

CONFERENCE CALENDAR

October 15-17

NATIONAL CONFERENCE OF STANDARDS LABORATORIES, Hilton Harvest House Hotel, Boulder, CO; sponsored by NBS, NCSL; contact: Ken Armstrong, 303/499-1000, ext. 3787.

***October 22-23**

USNC/CIE ANNUAL MEETING, NBS, Gaithersburg, MD; sponsored by NBS and CIE; contact: Jack Tech, B304 Metrology Building, 301/921-3864.

October 23-26

JOINT CONFERENCE ON MEASUREMENT AND STANDARDS FOR RECYCLED OIL/SYSTEMS PERFORMANCE AND DURABILITY, NBS, Gaithersburg, MD; sponsored by NBS, MFPG, ASTM Technical Division P on Recycled Petroleum Products and Lubricants; contact: Donald Becker, B50 Physics Building, 301/921-2621, or Harry Burnett, B265 Materials Building, 301/921-2812.

***November 5-9**

7TH WATER REACTOR SAFETY RESEARCH MEETING, NBS, Gaithersburg, MD; sponsored by NBS and NRC; contact: James Grundl, A157 Reactor Building, 301/921-2421.

***November 14-15**

ROBOTICS CONFERENCE, NBS, Gaithersburg, MD; sponsored by NBS; contact: James Albus, B129 Technology Building, 301/921-2382.

***November 27-30**

FIRE SAFETY FOR THE HANDICAPPED, NBS, Gaithersburg, MD; sponsored by NBS and HEW; contact: Robert Levin, B254 Physics Building, 301/921-3845.

December 3-5

1979 WINTER SIMULATION CONFERENCE, San Diego, California; sponsored by NBS, AIIE, ACM, IEEE, ORSA, TIMS, and SCS; contact: Paul Roth, B250 Technology Building, 301/921-2545.

***December 6**

IEEE ELECTRON DEVICES, NBS, Gaithersburg, MD; sponsored by NBS and IEEE; contact: Frank Oettinger, B312 Technology Building, 301/921-3621.

December 10-11

RESEARCH OPPORTUNITIES IN RESOURCE RECOVERY, NBS, Gaithersburg, MD; sponsored by NBS, DOE, NSF, National Center for Resource Recovery; contact: Joseph Berke, B326 Physics Building, 301/921-2343.

***December 10-11**

NBS-NCSBC JOINT CONFERENCE ON BUILDING REHABILITATION RESEARCH AND TECHNOLOGY FOR THE 1980's, Jack Tar Hotel, San Francisco, CA; sponsored by NBS, NBSBCS; contact: Sandra Berry, B226 Building Research Building, 301/921-2776.

December 12

COMPUTER NETWORKING SYMPOSIUM, NBS, Gaithersburg, MD; sponsored by NBS and IEEE; contact: Fran Nielsen, B212 Technology Building 301/921-2601.

1980

***May 5-7**

TOPICAL CONFERENCE ON BASIC OPTICAL PROPERTIES OF MATERIALS, NBS, Gaithersburg, MD.; sponsored by NBS in cooperation with OSA; contact: Albert Feldman, A251 Materials Building, 301/921-2840.

****May 13-15**

MEDILOG 80, NBS, Gaithersburg, MD; sponsored by NBS and DOD; contact: Charles Hulick, A740 Administration Building, 301/921-3465.

**New Listings*

***Conference originally scheduled for October 31-November 2, postponed to May 13-15, 1980.*

NEW STUDY TAKES A CLOSER LOOK AT ARSONISTS

*The Psychology of Firesetting: A Review and Appraisal, (NBS-GCR-79-157) is available for $5.25 from the National Technical Information Service, Springfield, VA 22161. Order by #PB 290 821.**

What makes arsonists tick? A recently released study sponsored by the Center for Fire Research at the National Bureau of Standards peers into the firesetter's mind and background and may help those seeking to answer that nagging question.

The Psychology of Firesetting: A Review and Appraisal, by two researchers at the University of North Carolina working under an NBS grant, summarizes what is known about arsonists—and the many gaps in our understanding of the firesetter. The study then presents a fresh approach for categorizing arsonists that has implications for arson prevention and treatment strategies. Using this approach, a portrait of the "typical" firesetter is painted.

The need to better comprehend the arsonist seems to be one of growing urgency. In 1964, there were 30 900 fires of confirmed or suspected incendiary origin which caused $60 million in direct losses. By 1974, the figures were 114 000 fires and $550 million in losses. A year later, those statistics had jumped to 144 000 such fires and $633 million in direct losses.

Part of a two-year study on arsonists funded by NBS, the new report notes that "Despite a rather large and diverse literature on firesetting, relatively little is understood about its determinants." The lack of knowledge is attributed in part to "the enormous difficulties in carrying out systematic, well-controlled research studies on firesetting. Legal difficulties in accessing samples of arsonists, the manner of legal disposition of arson cases, and the fact that relatively few arsonists are apprehended make it likely that research samples will be narrow and biased; it is not surprising that conclusions have often been contradictory and comparisons between groups have been extremely difficult."

The University of North Carolina researchers who did the study, Dr. Robert G. Vreeland and Dr. Marcus B. Waller, say that matters are made worse since previous methods for describing and classifying arsonists have usually been based arbitrarily on one aspect of the act, such as the firesetting motive, while other, potentially more important distinguishing features may have been overlooked. The new system described in the report is designed to overcome that limitation.

The report describes in detail the existing classifications and the available literature in each group. Some of the traditional categories covered in the study are arson-for-profit; solitary firesetters; motivated firesetting; pyromaniacs; and psychotic, group, female, and youthful firesetters.

A new classification approach is then spelled out, based on the four major factors associated with the act of arson: antecedent conditions, organismic factors, the actual firesetting behavior, and the consequences of the act. Antecedent conditions refer to the individual's physical and social environment and to events which may have precipitated the firesetting. Organismic factors are those personal variables which the individual brings into any situation—including such things as age, sex, intellectual abilities, genetic factors, physical disabilities, alcoholism, associated behavioral and psychiatric problems, and cognitive factors.

The actual firesetting behavior category takes into account the degree and sophistication of preparation, the materials used, the location of the fire, the structures burned, and whether the firesetter flees or remains at the scene of the fire. The final grouping, the consequences of the firesetting act, covers those events following the arson act which may serve to reward or otherwise maintain firesetting behavior—including the warmth and visual stimulation of the fire itself, the confusion created by the fire, praise from peers, praise from an authority for helping to put out the fire, and economic gains.

Making a first attempt to apply their new classification approach based on their literature survey, the researchers fashioned a composite of the "typical firesetter." This picture turns out to be of an individual with several maladaptive behavior patterns, of which firesetting is one. Among adults, social ineffectiveness is identified as a common factor in the firesetter's general tendency to have drinking, marital, occupational, and sexual problems and to exhibit a variety of other criminal and antisocial behavior. Youthful firesetters are said to have typically shown a number of problems, including stealing, hyperactivity, truancy, and aggression.

** Publications cited from this point on may be purchased at the listed price from the U.S. Government Printing Office, Washington, D.C. 20402 (foreign: add 25%). Microfiche copies are available from the National Technical Information Service, Springfield, VA 22161. For more complete periodic listings of all scientific papers and articles produced by NBS staff, write: Editor, Publications Newsletter, Administration Building, National Bureau of Standards, Washington, D.C. 20234.*

Building Technology

Gross, J. G., Pielert, J. H., and Cooke, P. W., Impact of Building Regulations on Rehabilitation —Status and Technical Needs, Nat. Bur. Stand. (U.S.), Tech. Note 998, 50 pages (May 1979) Stock No. 003-003-02062-1, $2.30.

Olmert, M., Center for Building Technology: A Perspective—1979, Nat. Bur. Stand. (U.S.), Spec. Publ. 439-1, 31 pages (May 1979) Stock No. 003-003-02056-7, $1.40.

Ruegg, R. T. ,and Chapman, R. E., Economic Evaluation of Windows in Buildings: Methodology, Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 119, 118 pages (Apr. 1979) Stock No. 003-003-02042-7, $3.

Simiu, E., Changery, M. J., and Filliben, J. J., Extreme Wind Speeds at 129 Stations in the Contiguous United States, Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 118, 318 pages (Mar. 1979) Stock No. 003-003-02041-9, $5.25.

Computer Science and Technology

Sockut, G. H., and Goldberg, R. P., Computer Science and Technology: Data Base Reorganization—Principles and Practice, Nat. Bur. Stand. (U.S.), Spec. Publ. 500-47, 51 pages (Apr. 1979) Stock No. 003-003-02055-9, $2.30.

Electromagnetic Metrology

Crawford, M. L., and Workman, J. L., Using a TEM Cell for EMC Measurements of Electronic Equipment, Nat. Bur. Stand. (U.S.), Tech. Note 1013, 72 pages (Apr. 1979) Stock No. 003-003-02053-2, $2.40.

Decker, W. F., Wilson, W. A., and Crawford, M. L., Construction of a Large Transverse Electromagnetic Cell, Nat. Bur. Stand. (U.S.), Tech. Note 1011, 92 pages (Feb. 1979) Stock No. 003-003-02034-6, $3.25.

Hoer, C. A., Calibrating a Six-Port Reflectometer with Four Impedance Standards, Nat. Bur. Stand. (U.S.), Tech. Note 1012, 24 pages (Mar. 1979) Stock No. 003-003-02036-2, $1.20.

Electronic Technology

Berning, D. W., Semiconductor Measurement Technology: A Reverse-Bias Safe Operating Area Transistor Tester, Nat. Bur. Stand. (U.S.), Spec. Publ. 400-54, 43 pages (Mar. 1979) Stock No. 003-003-02046-0, $1.70.

Dickey, D. H., and Ehrstein, J. R., Semi-Conductor Measurement Technology: Spreading Resistance Analysis for Silicon Layers with Nonuniform Resistivity, Nat. Bur. Stand. (U.S.), Spec. Publ. 400-48, 72 pages (May 1979) Stock No. 003-003-02061-3, $2.50.

Russell, T. J., and Maxwell, D. A., Semiconductor Measurement Technology: A Production-Compatible Microelectronic Test Pattern for Evaluating Photomask Misalignment, Nat. Bur. Stand. (U.S.), Spec. Publ. 400-51, 32 pages (Apr. 1979) Stock No. 003-003-02035-4, $1.50.

Energy Conservation and Production

Frohnsdorff, G. Brown, P. W., and Clifton, J. R., Possible Contributions of Cement and Concrete Technology to Energy Conservation, Nat. Bur. Stand. (U.S.), Spec. Publ. 542, 76 pages (May 1979) Stock No. 003-003-02059-1, $2.50.

Engineering, Product and Information Standards

Eisenhower, E. H., Chairman, ANSI Subcommittee N43, American National Standard N43.1; Radiological Safety in the Design and Operation of Particle Accelerators. (ANSI N43.1-1978), Nat. Bur. Stand. (U.S.), Handb. 107 Revised, 24 pages (May 1979) Stock No. 003-003-02064-8, $1.30.

Keysar, B. C., Specifications and Tolerances for Reference Standards and Field Standard Weights and Measures. 3. Specifications and Tolerances for Graduated Neck Type Volumetric Field Standards, Nat. Bur. Stand. (U.S.), Handb. 105-3 Revised, 23 pages (Mar. 1979) Stock No. 003-003-02044-3, $1.20.

Wollin, H. F., Barbow, L. E., and Heffernan, A. P., Report of the 63rd National Conference on Weights and Measures 1978, Nat. Bur. Stand. (U.S.), Spec. Publ. 532, 323 pages (Feb. 1979) Stock No. 003-003-02045-1, $4.25.

Fire Research

Glass, R. A., and Rubin, A. I., Fire Safety for High-Rise Buildings: The Role of Communications, Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 115, 47 pages (Apr. 1979) Stock No. 003-003-02016-8, $2.30.

Instrumentation and Experimental Methods

Fowler, J. B., Lind, M. A., and Zalewski, E. F., A Servo Controlled Electro-Optic Modulator for CW Laser Power Stabilization and Control, Nat. Bur. Stand. (U.S.), Tech. Note 987, 16 pages (Apr. 1979) Stock No. 003-003-02049-4, $1.10.

Mathematical and Statistical Methods

Gass, S. I., Ed., Utility and Use of Large-Scale Mathematical Models. Proceedings of a Workshop held at the National Bureau of Standards, Gaithersburg, MD, Apr. 28-29, 1977, Nat. Bur. Stand (U.S.), Spec. Publ. 534, 217 pages (May 1979) Stock No. 003-003-02060-5, $4.25.

Measurement Science and Technology Policy and State-of-the-Art Surveys

Peiser, H. S., Sangster, R. C., and Jung, W., Eds., Metrology in Industry and Government: How to Find Out Who Needs What Services. Proceedings of a Regional Seminar held at the Korea Standards Research Institute, Dae Jeon, Korea, Sept. 27-28, 1978, Nat. Bur. Stand. (U.S.), Spec. Publ. 539, 165 pages (Apr. 1979) Stock No. 003-003-02040-1, $3.75.

Sangster, R. C., Ed., The Technological Knowledge Base for Industrializing Countries. Proceedings of the NBS/AID UNCSTD Seminar held at the National Bureau of Standards, Gaithersburg, MD, Oct. 16-17, 1978, Nat. Bur. Stand. (U.S.), Spec. Publ. 543, 239 pages (Apr. 1979) Stock No 003-003-02057-5, $4.50.

Shorten, F. J., Ed., NBS Reactor: Summary of Activities—July 1977 to June 1978, Nat. Bur. Stand. (U.S.), Tech. Note 995, 147 pages (May 1979) Stock No. 003-003-02070-2, $4.50.

Mechanics: Design, Testing and Measurement

Snowdon, J.C., Vibration Isolation: Use and Characterization, Nat. Bur. Stand. (U.S.), Handb. 128, 129 pages (May 1979) Stock No. 003-003-02065-6, $4.

Standard Reference Data

Janz, G. J., Allen, C. B., Bansal, N.P., Murphy, R. M., and Tomkins, R.P.T., Physical Properties Data Compilations Revelant to Energy Storage. II. Molten Salts: Data on Single and Multi-Component Salt Systems, Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.), 61, Part II, 442 pages (Apr 1979) Stock No. 003-003-02051-6, $3.25.

Sieck, L. W., Rate Coefficients for Ion-Molecule Reactions. Organic Ions Other Than Those Containing Only C and H., Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (US), 64, 27 pages (Feb. 1979) Stock No. 003-003-02027-3, $1.30.

NEWS BRIEFS

NBS RESEARCH ACHIEVEMENTS. A new summary report of FY 1978 activities at NBS is now available. Included in the report are an overview of the Bureau's mission, research efforts and major accomplishments, special services and programs, a summary of legislation affecting the agency, a funds and facilities update, and a directory. National Bureau of Standards: A National Resource for Science and Technology is NBS Special Publication 538 and can be ordered from the U.S. Government Printing Office, Wash., D.C. 20402, SD Stock No. 003-003-02093-1 at a cost of $4.00.

CHANGES PROPOSED IN STANDARDS PROGRAM. Department of Commerce (DOC) has proposed substantial reductions in NBS's Voluntary Product Standards (VPS) program. All standards in the program would be withdrawn unless it is demonstrated that DOC sponsorship should continue for such reasons as substantial public impact or inability of private standards-writing groups to process or maintain the standard. New standards or revisions would not be undertaken, except under the same conditions. If DOC agrees to sponsor a project, NBS services would be provided on a cost-reimbursable basis.

RANDOM FAULTS IN INTEGRATED CIRCUITS. Tests in the NBS Center for Electronics and Electrical Engineering have shown that the location of random faults in complex microelectronic devices may be found using purely electrical measurements on a memory-type MOSFET array. The procedure would assist process engineers in determining the nature and density of random physical structure faults in complicated devices using comparatively simple measurements on the test structure.

PROPOSALS ON HIGHER LEVEL PROGRAMMING LANGUAGES, SOFTWARE QUALITY. Organizations interested in working on an expanded program to develop Federal computer standards for higher level programming languages and software quality are being sought by NBS for assistance. Proposals are now being accepted for specific projects to develop the foundations for future standards and to assess the benefits and costs. The projects will help the Bureau in assessing higher level programming lanugages and software quality, and in developing guidelines, validation methods, applicability criteria, and compliance monitoring methods for a comprehensive family of Federal standards for language and software development.

SULFATE AND NITRATE. NBS now has available a new Standard Reference Material developed for use in environmental analysis. Sulfate and Nitrate on Filter Media, SRM 2673, is one of a series of SRM's resulting from a program, sponsored jointly by NBS and the Environmental Protection Agency, that is aimed at producing reference materials to be used in monitoring the atmosphere. SRM 2673 can be purchased for $80 from the Office of Standard Reference Materials, NBS, Wash., D.C. 20234.

NEXT MONTH IN

DIMENSIONS/NBS

Corrosion is often called the cancer of metals. Each year corrosion costs the United States over $70 billion. Read about field tests that NBS researchers are conducting to help industry in the battle against rust in the next issue of DIMENSIONS/NBS.

U.S. DEPARTMENT OF COMMERCE
Juanita M. Kreps, Secretary

Jordan J. Baruch, Assistant Secretary for Science and Technology

NATIONAL BUREAU OF STANDARDS
Ernest Ambler, Director

Prepared by the Public Information Division
Washington, D.C. 20234

Richard S. Franzen, Chief

Sharon Washburn, Acting Chief
General Publications

Gail Porter, Acting Editor

Justine A. Williams, Assistant Editor

Stan Lichtenstein, Production Manager

Judy Fessler, Visual Editor
(Commerce Department)

PHOTO CREDITS

Mark Helfer, cover, pages 6, 17-19, 21-24, 25, top.
Richard Seek, page 25, bottom.

The Commerce Department's National Bureau of Standards was established by Congress in 1901 to advance the Nation's science and technology and to promote their application for public benefit. NBS research projects and technical services are carried out by the National Measurement Laboratory, the National Engineering Laboratory, and the Institute for Computer Sciences and Technology. Manufacturing, commerce, science, government, and education are principal beneficiaries of NBS work in the fields of scientific research, test method developments, and standards writing. DIMENSIONS/NBS describes the work of NBS and related issues and activities in areas of national concern such as energy conservation, fire safety, computer applications, materials utilization, and consumer product safety and performance. The views expressed by authors do not necessarily reflect policy of the National Bureau of Standards or the Department of Commerce.

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Annual subscription: Domestic, $11.00, foreign, $13.75. Single copy: Domestic, $1.10, foreign, $1.40. The Secretary of Commerce has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director of the Office of Management and Budget through June 30, 1981.